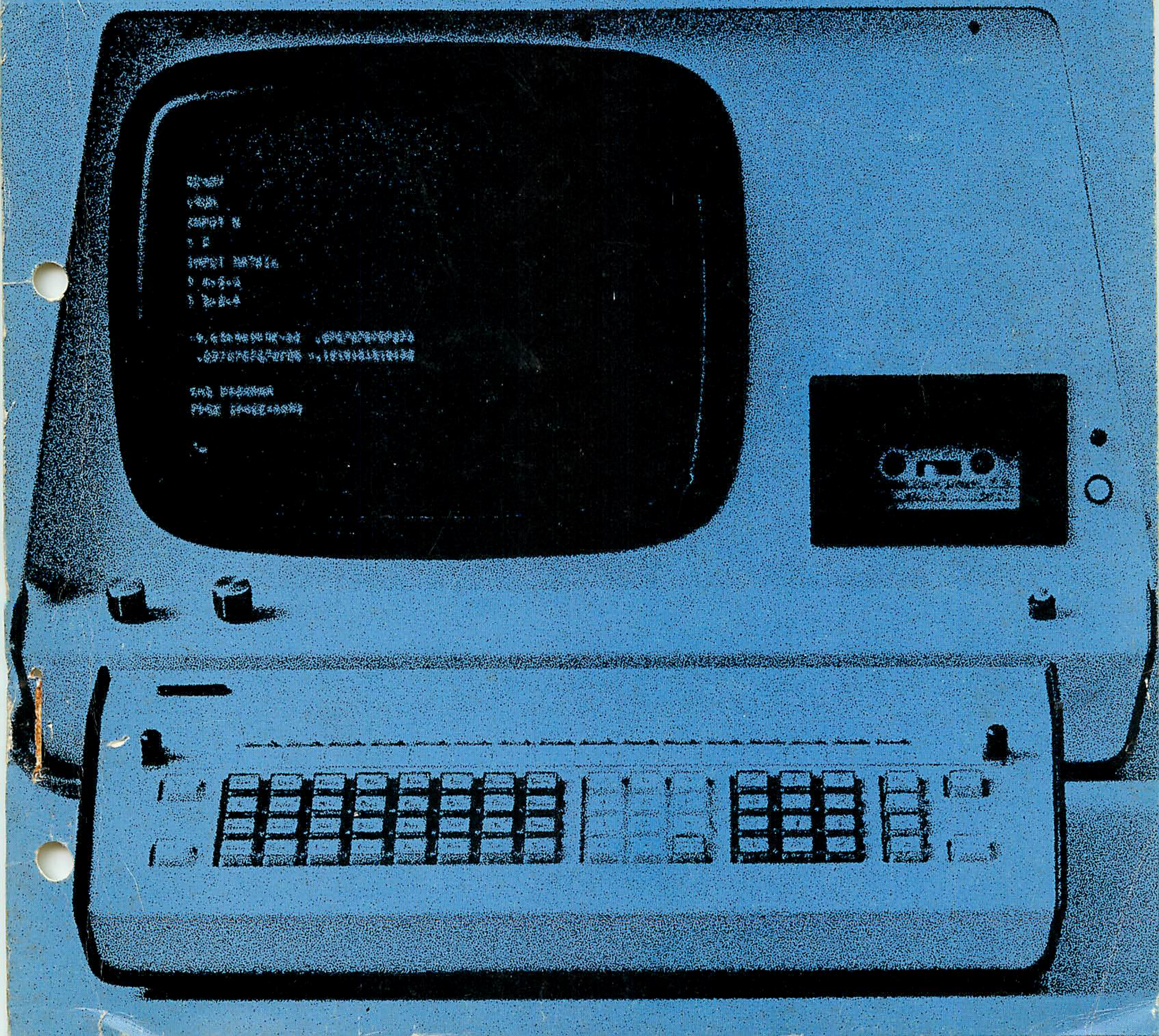
WANG

NONPARAMETRIC STATISTICS OPERATOR'S MANUAL

SYSTEM 2200



Nonparametric Statistics

Operator's Manual

WANG LABORATORIES, INC.

836 NORTH STREET, TEWKSBURY, MASSACHUSETTS 01876, TEL. (617) 851-4111, TWX 710 343-6769, TELEX 94-7421

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836 NORTH STREET TEWKSBURY MASSACHUSETTS 01876 TEL (617) 851 4111 TWX 710 343 6769 TELEX 94 7421

HOW TO USE THIS MANUAL

This manual consists of two parts: PART I containing a menu program, a utility program and thirteen nonparametric programs; Part II consisting of a menu program and twelve nonparametric programs. Chapter titles give the names of the type of tests available.

There are four Nonparametric Statistics System Tape Cassettes; two are designed for the System 2200A/B/C; and two are designed for the System 2200S. If any questions arise concerning the operation of these systems, refer to the appropriate reference manual.

INTRODUCTION

The Nonparametric Statistics Library is intended to be a "set-it-and-forget-it" system. The user loads the desired program into the System 2200 memory, enters the values relevant to his problem, and allows the System 2200 to do the rest.

The main reference used in the development of this fully automated system was "Nonparametric Statistics for the Behavorial Sciences", by S. Siegel. Most of the techniques explained in Siegel's text are fully automated in this library.

The Wang output printers label all data in a clear and concise manner, thus providing the user with a permanent record of calculated results.

The Nonparametric Statistics Library has been developed for use on the System 2200A/B/C and the System 2200S. In this document, the System 2200A/B/C is referred to as System A and the System 2200S is referred to as System S.

LEVEL OF MEASUREMENT	ONE-SAMPLE CASE	TWO-SAMPLE CASE		k-SAMPLE CASE		MEASURES OF CORRELATION
		RELATED SAMPLE	INDEPENDENT SAMPLE	RELATED SAMPLE	INDEPENDENT SAMPLE	
Nominal	Binomial Test χ^2 Test	McNemar Test	Fisher Test χ^2 Test	Cochran Q Test	χ^2 Test	Contingency Coefficient: C
Ordinal	Kolmogorov-Smirnov Test Runs Test	Sign Test Wilcoxon Test	Median Test Mann-Whitney U Test Kolmogorov-Smirnov Test Wald-Wolfowitz Test	Friedman Test	Median Test Kruskal-Wallis Test	Spearman Test: r_s Kendall Test: τ Kendall Partial Test: $\tau_{xy.z}$ Kendall Test: W
Interval		Walsh Test				

NOTE:

In terms of the tests, not including those for correlation, each program is applicable also for the level of measurement below it. In other words, the programs for the nominal level are also applicable for the ordinal and interval levels. The test names are abbreviated due to lack of space.

In the Wilcoxon Test, the pair differences must also be from an ordinal scale as well as the paired values.

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CHAPTER I MENU FOR PART I

PROGRAM ABSTRACT

This program contains a routine for accessing any one of the first 14 programs and a routine for initializing scratch cassettes.

PROGRAM DESCRIPTION

The MENU program for Part I is designed to display the first 14 programs of the Nonparametric Statistics package. After loading and starting, the first 7 programs are displayed. These programs are numbered 00-06; the numbers represent the Special Function key used to access the desired program. If the desired program does not fall within the first 7 programs, touch RETURN(EXEC) to display the remaining programs of Part I. The remaining programs are numbered 07-13; the numbers represent the Special Function key used to access the desired program.

After depressing the appropriate Special Function key, a prompt appears which asks whether or not the user wishes to initialize scratch cassettes. Initializing a scratch cassette places a software header record at the beginning of the tape which permits the scratch cassette to be used as a data cassette. Data cassettes can be reused as scratch cassettes without reinitializing. After initializing the necessary number of cassettes or, if the prompt was answered negatively, the selected program is loaded.

Each program provides the option of bypassing the MENU program. In bypassing the MENU program, the option to initialize data cassettes is not available.

DISPLAYS	INSTRUCTIONS

MENU FOR PART I

1. Mount the Nonparametric Statistics System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).

2a. KEY S.F. KEY TO ACCESS PROGRAM OR RETURN(EXEC) FOR REST OF MENU
?_

S.F.	DESCRIPTION
00	UTILITY PROGRAM
01	THE BINOMIAL TEST
02	THE CHI-SQUARE ONE-SAMPLE TEST
03	THE KOLMOGOROV-SMIRNOV ONE-SAMPLE TEST
04	THE ONE-SAMPLE RUNS TEST
05	THE MCNEMAR TEST FOR THE SIGNIFICANCE OF CHANGES
06	THE SIGN TEST

2a. Key a Special Function (S.F.) key to access a desired program or touch RETURN(EXEC) to display the remainder of the menu.

2b. KEY S.F. KEY TO ACCESS PROGRAM
?_

S.F.	DESCRIPTION
07	THE WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST
08	THE WALSH TEST
09	THE FISHER EXACT PROBABILITY TEST
10	THE CHI-SQUARE TEST FOR TWO INDEPENDENT SAMPLES
11	THE MEDIAN TEST
12	THE MANN-WHITNEY U TEST
13	THE KOLMOGOROV-SMIRNOV TWO-SAMPLE TEST

2b. Key S.F. key to access desired program.

DISPLAYS	INSTRUCTIONS
3. DO YOU DESIRE TO INITIALIZE SCRATCH TAPES (Y OR N) ?_	3. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', the system loads the selected program.

DISPLAYS	INSTRUCTIONS
	NOTE: The message RE-ENTER appears if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC).
4. REMOVE PROGRAM CASSETTE FROM LOGICAL UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	4. After removing System Tape #1, touch RETURN(EXEC).
5. MOUNT SCRATCH CASSETTE TO BE LABELED IN LOGICAL UNIT 1 (E=END) KEY RETURN(EXEC) TO RESUME ?_	5. After mounting a scratch cassette, touch RETURN(EXEC). If no more scratch cassettes are to be initialized, type E, touch RETURN(EXEC) and go to the next step.
6. MOUNT PROGRAM CASSETTE IN LOGICAL UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	6. After mounting System Tape #1, touch RETURN(EXEC).
	NOTE: At this time, the selected program is loaded with an appropriate message, for example: LOADING THE KOLMOGOROV-SMIRNOV TWO-SAMPLE TEST

CHAPTER II THE UTILITY PROGRAM

PROGRAM ABSTRACT

This program contains routines for copying data from one array into another array, sorting an array of data, finding the median of a sorted array of data or sorted rank array, determining the average rank values of a data array with tied observations, and placing the rank values in the same order as the data input.

PROGRAM DESCRIPTION

The Utility program contains five routines which are used in the Nonparametric Programs. These five routines are:

(1) Copying the data from one array into another array.

(2) Sorting an array of data.

(3) Determining the median value for a data set or set of ranks.

(4) Determining the average rank values for a set of data.

(5) Positioning the average rank values in the order of the input data.

Let us look at these routines individually.

Routine 1 copies the data from one array into another array. This is a simple recall-store data operation which ends with two arrays containing the same data.

Routine 2 sorts a specified array of data. The technique employed is to compare positions of data items. In other words, the smallest item is found in the first pass by comparing the first item with each (N-1) item in the rest of the array. Once the smallest item has been found, it is swapped with the first item. The second pass starts with the second item in the row and is compared with the (N-2) items remaining. This process is repeated until the array is sorted.

Routine 3 determines the median value in an array of sorted data items or sorted rank values. The method is simply to determine the middle address in the array field and recall the value. If the array has an even number of elements, the middle two addresses are found and their contents recalled and averaged together.

Routine 4 assigns initial rank values and then computes the average rank values if there are any repeated values in the data. These ranks are stored in another array in sorted order. In some of the nonparametric tests, if there are tied groups of data in the sample, the formula has a correction term added to it. The term has a couple of forms but the most common one used here is:

$$T = \sum \frac{t^3 - t}{12}$$

where t is the number of tied values in the group.

Routine 5 places in another array the average rank values in the order of the input data. During this routine, the array of input data is filled with values.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameter:

N = 64 where N = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of N:

   $(4 \times N) \leq$ the number of variables available.

2. Select the appropriate value of N for your system from the following table:

CAPACITY	8K	12K	16K
N for System A	64	192	255

3. Insert System Tape #1 into Unit 1 (on the Console), close the door and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS100AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).
   The screen should display:

```
170 DIM X(64),S(64),A(64),P(64):
    SELECT #110A:D=32
```

6. Rekey statement, using the new maximum parameters:

```
170 DIM X(N),S(N),A(N),P(N):SELECT #110A:
    D=32
```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS100AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Use the following data set to show the Utility Program.

86	69	65	65	113	65
118	45	141	104	41	50
55	40	22	65	16	7
9	16	26	36	20	15

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN (EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS100AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?----------------	2. Enter project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter date and touch RETURN (EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

Example

Use the following data set to show the Utility Program.

86	69	65	65	113	65
118	45	141	104	41	50
55	40	22	65	16	7
9	16	26	36	20	15

DISPLAY	INSTRUCTIONS
	NOTE: The test information is displayed for verification. The message RE-ENTER appears if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF THE NPS1F000 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETER ENTER SAMPLE SIZE ?_	9. Sample Size = 24, touch RETURN(EXEC).
10. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9. NOTE: The parameter is displayed for verification.
11. DATA INPUT FOR SAMPLE ITEM #1 ENTER DATA VALUE ?_	11. Sample item #1 = 86, touch RETURN(EXEC).

Example

Use the following data set to show the Utility Program.

86	69	65	65	113	65
118	45	141	104	41	50
55	40	22	65	16	7
9	16	26	36	20	15

DISPLAYS	INSTRUCTIONS
12. DATA INPUT FOR SAMPLE ITEM #2 ENTER DATA VALUE ?_	12. Sample item #2 = 69, touch RETURN(EXEC).

Enter all items in the example.

DISPLAYS	INSTRUCTIONS
13. CORRECTION ROUTINE FOR ITEMS #1-24 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 14. If 'N', go to Section III. NOTE: The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, type 'Y' and touch RETURN (EXEC).
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F000 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 15.
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?__ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER (2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	16. Enter output device type symbol and touch RETURN(EXEC).

Example

Use the following data set to show the Utility Program.

86	69	65	65	113	65
118	45	141	104	41	50
55	40	22	65	16	7
9	16	26	36	20	15

DISPLAYS	INSTRUCTIONS
17. MOUNT VOL 1 OF FILE NPS1F000 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. After mounting the indicated cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step, and go to step 18b.
18a. READING DATA RECORD b. CREATING WORK AREAS c. SORTING DATA d. SETTING UP AVERAGE RANKS e. ALIGNING AVERAGE RANKS f. READING DATA RECORD	18. The system displays screen messages for each routine as it is being performed. If CRT output is chosen after all routines have been executed, the system displays the results for verification. Touch RETURN(EXEC) to continue. NOTE: If any of the output printers was selected, the message PRINTING RESULTS is displayed.
19. STOP END OF PROGRAM :_	19. The Utility program is complete.
	20. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

DISPLAYS	INSTRUCTIONS
A. INPUT INFORMATION DO YOU WISH TO CORRECT DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 16.

Example

Use the following data set to show the Utility Program.

86	69	65	65	113	65
118	45	141	104	41	50
55	40	22	65	16	7
9	16	26	36	20	15

DISPLAYS	INSTRUCTIONS

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F000 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. After mounting the indicated cassette, touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F000-UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. After mounting scratch cassette, touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR ITEMS #1-24 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 14. If 'N', go to Section III. NOTE: The input data is displayed for verification.

SECTION III
DATA CORRECTION ROUTINE

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR ITEMS #1-24 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the item number of the incorrect value and touch RETURN (EXEC).
B. CORRECTION ROUTINE FOR ITEMS #1-24 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC).

Example

Use the following data set to show the Utility Program.

86	69	65	65	113	65
118	45	141	104	41	50
55	40	22	65	16	7
9	16	26	36	20	15

DISPLAYS	INSTRUCTIONS
	NOTE: Follow steps A and B for all items. If branching from step 13, that step reappears. Follow the appropriate operating instructions. If branching from Section II, step C, that step reappears. Follow the appropriate operating instructions.

Sample Output

```
UTILITY PROGRAM
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


SAMPLE SIZE =  24

DATA INPUT

 86          69          65          65          113
 65          118         45          141         104
 41          50          55          40          22
 65          16          7           9           16
 26          36          20          15

UTILITY PROGRAM
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


SAMPLE SIZE =  24

SORTED DATA

 7           9           15          16          16
 20          22          26          36          40
 41          45          50          55          65
 65          65          65          69          86
 104         113         118         141

          DATA MEDIAN =  47.5
```

UTILITY PROGRAM
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

SAMPLE SIZE = 24

AVERAGE RANKS

1	2	3	4.5	4.5
6	7	8	9	10
11	12	13	14	16.5
16.5	16.5	16.5	19	20
21	22	23	24	

RANK MEDIAN = 12.5

CORRECTION TERM = 5.5

UTILITY PROGRAM
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

SAMPLE SIZE = 24

ALIGNED RANKS

20	19	16.5	16.5	22
16.5	23	12	24	21
11	13	14	10	7
16.5	4.5	1	2	4.5
8	9	6	3	

END OF PROGRAM

CHAPTER III THE BINOMIAL TEST

PROGRAM ABSTRACT

The program performs a goodness-of-fit test when there are just two categories in the classification of data. It tests the hypothesis that the sample was drawn from a population with a specified distribution. It is uniquely useful with a small sample size. The data can be measured in either a nominal or ordinal scale.

PROGRAM DESCRIPTION

In the one-sample case in statistics, the common parametric test used is the t-test. This test is employed upon the difference between the observed (sample) and expected (population) means. However, the t-test requires that the sample data is generated from a normally distributed population and that the data is measured in at least an interval scale. But this test is inapplicable in many sorts of data. There are several nonparametric tests which can be applied in its place. One such test is the Binomial Test.

There are populations of data which fall into only two discrete classes. If we know that the proportion in one class is P, then the proportion in the other is 1-P or Q. This value of P is fixed within one population but may vary from population to population. However, when making a random sample from a population, it is conceivable that the sample values of P and Q are different from the values for the population. For example, half the population is male and half is female. However, our random sample may contain 45 percent male and 55 percent female or 60 percent male and 40 percent female. These differences from the population arise by chance and are usually small. The binomial distribution is a test used to see if the sample could have been drawn from a population with a specified value P. The test is of a goodness-of-fit nature. When the data is from two classes, then we are testing the null hypothesis, H , that the population value is P.

In determining the chance of obtaining x items in one class and N-x items in the other class, the probability of x, p(x), is found by:

$$p(x) = \binom{N}{x} P^{x} Q^{N-x}$$

where P = expected proportion in one class.

Q = expected proportion in the other class.

N = size of sample.

$\binom{N}{x} = \frac{N!}{x!\,(N-x)!}$ the binomial coefficient.

However, we usually are more interested in determining the probability of obtaining the observed value and values even more extreme. We determine $p(x \le x_n)$ by:

$$p(x \le x_n) = \sum_{i=0}^{x_n} \binom{N}{i} P^i Q^{N-i}$$

To find the probability of the observed value or values more extreme, we have three possible case approaches.

1) If $N \le 25$ and $P = Q = 1/2$, there is a table of probabilities for an observed x.

2) If $N \le 25$ and $P \ne Q$, we use the formula for $p(x \le x_n)$ previously discussed and generate the values.

3) If $N > 25$ and P is close to 1/2 we can use the formula.

$$z = \frac{(x_n \pm .5) - NP}{\sqrt{NPQ}}$$

where $(x_n + .5)$ when $x_n < NP$ and $(x_n - .5)$ when $x_n > NP$. The $(\pm .5)$ is a correction for continuity. z is approximately normal N(0,1).

For this program, since case (1) and (3) are so restricted in the conditions needed in order to use them, they were ignored and the program generates values for all cases using the formula for $p(x \le x_n)$.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 160 of the program. By changing Statement 160, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

As it is sold, the program contains the following maximum parameters:

N = 254, where N = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of N:

   $(N+1) \le$ the number of variables available.

2. Select the appropriate value of N for your system from the following table:

CAPACITY	4K	8K
N for System A	94	254

3. Insert System Tape #1 into Unit 1 (on the Console), close the door and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS101AA", and touch RETURN(EXEC).

5. Key LIST 160, and touch RETURN(EXEC).
   The screen should display:

   ```
   160 DIM S(255):SELECT #110A
   ```

6. Rekey statement using the new maximum parameters:

   ```
   160 DIM S(N+1):SELECT #110A
   ```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS101AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use the System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Suppose we roll a fair dice seven times. What is the chance that three rolls will show "six" exactly? What is the chance of three or fewer "sixes"?

P = .166666, N = 7, x = 3

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN, RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS101AA" and touch RETURN(EXEC). Touch RUN, RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?------------------------------	3. Enter user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

Example

Suppose we roll a fair dice seven times. What is the chance that three rolls will show "six" exactly? What is the chance of three or fewer "sixes"?

P = .166666, N = 7, x = 3

DISPLAYS	INSTRUCTIONS
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT DATA ENTER EXPECTED PROPORTIONS IN ONE CASE (P) ?_	6. Proportions = .166666, touch RETURN(EXEC).
7. INPUT DATA ENTER SAMPLE SIZE (N) ?_	7. Sample size = 7, touch RETURN(EXEC).
8. INPUT DATA ENTER OBSERVED VALUE (X) ?_	8. Observed value = 3, touch RETURN(EXEC).
9. INPUT DATA INPUT DATA OK (Y OR N) ?_	9. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 6.
	NOTE: The input data is displayed for verification.
10. ENTER OUTPUT DEVICE TYPE SYMBOL ?_- FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	10. Enter output device type symbol and touch RETURN(EXEC).

Example

Suppose we roll a fair dice seven times. What is the chance that three rolls will show "six" exactly? What is the chance of three or fewer "sixes"?

P = .166666, N = 7, x = 3

DISPLAYS	INSTRUCTIONS
11. EXECUTING PROGRAM	11. The system now is executing the Binomial test.
	NOTE: If one of the output printers was selected, the message PRINTING RESULTS is displayed.
12. STOP END OF PROGRAM :_	12. The test results are displayed for verification.
	13. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to Step 2.

Sample Output

```
THE BINOMIAL TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


P =  .166666
N =  7
X =  3


PROBABILITIES:  I              P(I)
                 0              .2790832101
                 1              .3907146187019
                 2              .2344276459601
                 3             7.81421735E-02


       P( 3 ) =  7.81421735E-02
P(X .LE. 3 ) =  .9823676483311


END OF PROGRAM
```

CHAPTER IV THE CHI-SQUARE ONE-SAMPLE TEST

PROGRAM ABSTRACT

The program performs a goodness-of-fit test for the null hypothesis that the sample is from a population with a specified distribution. The data falls in k discrete categories and the expected frequencies are large. Data can be measured in either a nominal or ordinal scale.

PROGRAM DESCRIPTION

In the one-sample case in statistics, the common parametric test used is the t-test. This test is employed upon the difference between the observed (sample) and expected (population) means. However, the t-test requires that the sample data is generated from a normally distributed population and that the data is measured in at least an interval scale. But this test is inapplicable in many sorts of data. There are several nonparametric tests which can be applied in its place. One such test is the χ^2 One-Sample Test.

Often there are populations of data that fall into various categories, which would be of interest to a researcher. For example, an opinion poll would take the responses and place them into categories such as "In Favor", "Opposed", or "Indifferent". The frequency within each category would be observed and interpreted for meaning. The χ^2 test analyzes data sets like this. There are k categories and the analysis is of a goodness-of-fit type where the observed frequencies within each category are compared with the expected frequencies based upon a null hypothesis, (H_0). Is there a significant difference?

Based upon the null hypothesis, (H_0), we can deduce what the expected frequencies are from the presumed population. Then comparing each with the observed frequencies, we test for significant difference. We can test using the following formula:

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

where O_i = observed frequency in ith category.

E_i = expected frequency in ith category.

k = no. of categories.

If there is little difference between the observed and expected frequencies, then the value of χ^2 will be small. If there are large differences, χ^2 will be large. The larger the differences or the larger the value of χ^2, the more the implication is that the observed population of data does not come from the presumed population of the null hypothesis.

The χ^2 sampling distribution under H_0 follows the Chi-Square distribution with (k-1) degrees of freedom. Thus we can use the Chi-Square tables to find the associated probabilities of occurrence for each χ^2.

Limitations of the χ^2 Test

a) When k=2, each expected frequency should be at least 5.

b) When k>2 and more than 20% of the expected frequencies (E_i) are less than five or any one expected frequency (E_i) is 0, combine categories to increase expected frequencies (E_i).

If the data cannot meet restrictions, try the BINOMIAL TEST.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

N = 196, where N = # of categories.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of N:

   $(2*N) \leq$ the number of variables available.

2. Select the appropriate value of N for your system from the following table:

CAPACITY	8K	12K
N for System A	196	255

3. Insert System Tape #1 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS102AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).
   The screen should display:

   ```
   170 DIM  O(196),E(196):SELECT #110A
   ```

6. Rekey statement using the new maximum parameters:

   ```
   170 DIM  O(N),E(N):SELECT #110A
   ```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS102AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Suppose we desire to test if the Post Position is significant in a race. Over 19 days and N = 162 winners (9/day), the following data was collected:

Post	1	2	3	4	5	6	7	8	9
Wins	39	30	14	25	7	15	10	16	6
E	18	18	18	18	18	18	18	18	18

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS102AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Suppose we desire to test if the Post Position is significant in a race. Over 19 days and N = 162 winners (9/day), the following data was collected:

Post	1	2	3	4	5	6	7	8	9
Wins	39	30	14	25	7	15	10	16	6
E	18	18	18	18	18	18	18	18	18

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F020 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch tape and touch RETURN(EXEC).
9. INPUT PARAMETER ENTER # OF CATEGORIES ?_	9. Categories = 9, touch RETURN (EXEC).
10. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.

Example

Suppose we desire to test if the Post Position is significant in a race. Over 19 days and N = 162 winners (9/day), the following data was collected:

Post	1	2	3	4	5	6	7	8	9
Wins	39	30	14	25	7	15	10	16	6
E	18	18	18	18	18	18	18	18	18

DISPLAYS	INSTRUCTIONS
	NOTE: The number of categories is displayed for verification.
11. DATA INPUT FOR CATEGORY #1 ENTER OBSERVED FREQUENCY VALUE ?_	11. Observed frequency value = 39, touch RETURN(EXEC).
12. DATA INPUT FOR CATEGORY #1 ENTER EXPECTED FREQUENCY VALUE ?_	12. Expected frequency value = 18, touch RETURN(EXEC).
13. CORRECTION ROUTINE FOR CATEGORY #1 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or, to enter more data, go to step 11. If 'N', go to Section III.
	NOTE: The input data is displayed for verification. Follow steps 11-13 for all categories.

Enter all items in the example.

DISPLAYS	INSTRUCTIONS
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F020 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC).
	NOTE: If step 7 was answered negatively, ignore this step and go to step 15.
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC).

Example

Suppose we desire to test if the Post Position is significant in a race. Over 19 days and N = 162 winners (9/day), the following data was collected:

Post	1	2	3	4	5	6	7	8	9
Wins	39	30	14	25	7	15	10	16	6
E	18	18	18	18	18	18	18	18	18

DISPLAYS	INSTRUCTIONS
	If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?-- FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	16. Enter output device type symbol and touch RETURN(EXEC).
17. MOUNT VOL 1 OF FILE NPS1F020 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. After mounting the indicated cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 18b.
18a. READING DATA RECORD	18a. The system now is reading the data record.
b. EXECUTING PROGRAM	b. The system now is performing the Chi-Square One-Sample test. NOTE: If one of the output printers was selected, the message PRINTING RESULTS is displayed.
19. STOP END OF PROGRAM :_	19. The test results are displayed for verification.
	20. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

Example

Suppose we desire to test if the Post Position is significant in a race. Over 19 days and N = 162 winners (9/day), the following data was collected:

Post	1	2	3	4	5	6	7	8	9
Wins	39	30	14	25	7	15	10	16	6
E	18	18	18	18	18	18	18	18	18

DISPLAYS	INSTRUCTIONS

SECTION I
DATA FROM STORAGE

DISPLAYS	INSTRUCTIONS
A. DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 16.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F020 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. After mounting the indicated cassette, touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F020-UNIT 1 ?_	B. After mounting a scratch cassette, touch RETURN(EXEC).
C. ENTER CATEGORY # IN ERROR (0 IF END) ?_	C. Enter the number of the category in error or 0, and touch RETURN(EXEC). If a category is entered, go to the next step. If '0', go to step 14.
D. CORRECTION ROUTINE FOR CATEGORY #1 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step C. If 'N', go to Section III. NOTE: The input data is displayed for verification.

Example

Suppose we desire to test if the Post Position is significant in a race. Over 19 days and N = 162 winners (9/day), the following data was collected:

Post	1	2	3	4	5	6	7	8	9
Wins	39	30	14	25	7	15	10	16	6
E	18	18	18	18	18	18	18	18	18

DISPLAYS	INSTRUCTIONS

SECTION III
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR CATEGORY # 1 ENTER CORRECT OBSERVED FREQUENCY VALUE ?_	A. Enter correct value and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR CATEGORY #1 ENTER CORRECT EXPECTED FREQUENCY VALUE ?_	B. Enter correct value and touch RETURN(EXEC).

NOTE:

Follow steps A and B for all categories.

If branching from step 13, that step reappears. Follow the appropriate operating instructions.

If branching from Section II, step D, that step reappears. Follow the appropriate operating instructions.

Sample Output

THE CHI-SQUARE ONE-SAMPLE TEST
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

OF CATEGORIES = 9

I	O(I)	E(I)	X(I)
1	39	18	24.5
2	30	18	8
3	14	18	.888888888889
4	25	18	2.72222222222
5	7	18	6.72222222222
6	15	18	.5
7	10	18	3.55555555556
8	16	18	.222222222222
9	6	18	8

CHI-SQUARE = 55.1111111109
D.F. = 8

END OF PROGRAM

CHAPTER V THE KOLMOGOROV-SMIRNOV ONE-SAMPLE TEST

PROGRAM ABSTRACT

The program performs a goodness-of-fit test for the null hypothesis that the sample is from a population with a specified distribution. It is used when one can assume that the variable has a continuous distribution. Even if the variable has a discontinuous distribution, it can be used since the error is in a safe direction. It treats data individually, no group effect, and is the most powerful of the goodness-of-fit tests.

PROGRAM DESCRIPTION

In the one-sample case in statistics, the common parametric test used is the t-test. This test is employed upon the difference between the observed (sample) and expected (population) means. However, the t-test required that the sample data is generated from a normally distributed population and that the data is measured in at least an interval scale. But this test is inapplicable in many sorts of data. There are several nonparametric tests which can be applied in its place. One such test is the Kolmogorov-Smirnov One-Sample test. This is a goodness-of-fit test which views the degree of agreement between the distribution of an observed set of data and some theoretical distribution. Does the observed data values come from the theoretical population?

By specifying the cumulative frequency distribution occurring under the theoretical distribution and comparing that with the observed cumulative frequency distribution, we can determine the point of greatest divergence. The sampling distribution indicates if this value is possible and then if the random sample was really from the theoretical distribution. For example, suppose we want to see if people have preference in shades of one color. Suppose we have five different shades of one color and we ask ten people to pick their choice of shades. If there is no preference in color shade, then each shade would be chosen about the same number of times, except for random differences. If preference in shade is important, then one of the extreme ranks would be consistently chosen.

Let $F_0(X)$ = a completely specified cumulative frequency distribution function, the theoretical distribution under H_0. For any X, $F_0(X)$ is the expected number of cases to have values less than or equal to X. Let $S_N(X)$ = the observed cumulative frequency distribution of random sample with N observations. $S_N(X) = k/N$ where k is the number of observations less than or equal to X. To determine the maximum deviation D, we use the formula:

$$D = \text{Maximum} \left| F_0(X) - S_N(X) \right|$$

Under the null hypothesis, the difference between each theoretical value $F_0(X)$ and each observed value $S_N(X)$ should be small and within the limits of random error. Since the sampling distribution of D under the null hypothesis is known, there is a table with critical values available for two-tailed tests. P(S) is the observed cumulative frequency of a random sample with N observations. The exact value is the $S_N(X)$ value related to the maximum deviation (D).

Example

Suppose we have five shades of a color. We have ten people choose a shade. Is there a shade preference?

SHADE	1	2	3	4	5
f	1	0	6	1	2

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS103AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

Example

Suppose we have five shades of a color. We have ten people choose a shade. Is there a shade preference?

SHADE	1	2	3	4	5
f	1	0	6	1	2

DISPLAYS	INSTRUCTIONS
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' or STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F030 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch tape and touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER # OF CHOICES ?_	9. The number of choices = 5, touch RETURN(EXEC).
10. INPUT PARAMETERS ENTER # OF OBSERVATIONS ?_	10. The number of observations = 10, touch RETURN(EXEC).
11. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
	NOTE: The input information is displayed for verification.

Example

Suppose we have five shades of a color. We have ten people choose a shade. Is there a shade preference?

SHADE	1	2	3	4	5
f	1	0	6	1	2

DISPLAYS	INSTRUCTIONS
12. DATA INPUT FOR CHOICE #1 ENTER OBSERVED FREQUENCY VALUE ?_	12. Observed frequency value = 1, touch RETURN(EXEC).
13. DATA INPUT FOR CHOICE #2 ENTER OBSERVED FREQUENCY VALUE ?_	13. Observed frequency value = 0, touch RETURN(EXEC).

Enter all items in the example.

DISPLAYS	INSTRUCTIONS
14. CORRECTION ROUTINE FOR ITEMS #1-5 IS DATA OK (Y OR N) ?_	14. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.
15. REMOVE AND LABEL VOL 1 OF FILE NPS1F030-UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	15. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 16.
16. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	16. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 20.
17. ENTER OUTPUT DEVICE TYPE SYMBOL ?__ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	17. Enter output device type symbol and touch RETURN(EXEC).

Example

Suppose we have five shades of a color. We have ten people choose a shade. Is there a shade preference?

SHADE	1	2	3	4	5
f	1	0	6	1	2

DISPLAYS	INSTRUCTIONS
18. MOUNT VOL 1 OF FILE NPS1F030 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	18. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 19b.
19a. READING DATA RECORD	19a. The system now is reading the data record.
b. EXECUTING PROGRAM	b. The system now is performing Kolmogorov-Smirnov One-Sample test. NOTE: If one of the output printers was selected, the message PRINTING RESULTS is displayed.
20. STOP END OF PROGRAM :_	20. The test results are displayed for verification.
	21. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC), and go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 17.

Example

Suppose we have five shades of a color. We have ten people choose a shade. Is there a shade preference?

SHADE	1	2	3	4	5
f	1	0	6	1	2

DISPLAYS	INSTRUCTIONS

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F030 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. After mounting the indicated cassette, touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F030 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. After mounting a scratch cassette, touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR ITEMS #1-5 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 15. If 'N', go to Section III.

SECTION III
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR ITEMS #1-5 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the item # of the incorrect value and touch RETURN(EXEC). NOTE: Items 1-5 are displayed for verification.
B. CORRECTION ROUTINE FOR ITEMS #1-5 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC).

Example

Suppose we have five shades of a color. We have ten people choose a shade. Is there a shade preference?

SHADE	1	2	3	4	5
f	1	0	6	1	2

DISPLAYS	INSTRUCTIONS
	NOTE: Follow steps A and B for all items. If branching from step 14, that step reappears. Follow the appropriate operating instructions. If branching from Section II, step C, that step reappears. Follow the appropriate operating instructions.

Sample Output

```
THE KOLMOGOROV-SMIRNOV ONE-SAMPLE TEST
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


     # OF CHOICES =   5
# OF OBSERVATIONS =   10


I              F              F(X)           S(X)           D
 1              1              .2             .1             .1
 2              0              .4             .1             .3
 3              6              .6             .7             .1
 4              1              .8             .8            0
 5              2             1              1              0


MAX D =  .3
 P(S) =  .1


END OF PROGRAM
```

CHAPTER VI THE ONE-SAMPLE RUNS TEST

PROGRAM ABSTRACT

The program is used to test for the randomness of the sequence of data items in a sample.

PROGRAM DESCRIPTION

In the one-sample case in statistics, the common parametric test used is the t-test. This test is employed upon the difference between the observed (sample) and expected (population) means. However, the t-test requires that the sample data is generated from a normally distributed population and that the data is measured in at least an interval scale. But this test is inapplicable in many sorts of data. There are several nonparametric tests which can be applied in its place. One such test is the One-Sample Runs Test. In order to arrive at some conclusion about a population by using information from a sample from that population, the sample must be random. How do we tell if a sample is random or not? The techniques used are based upon the order or sequence of the data. The One-Sample Runs Test is based upon the number of runs in the sample. A run is a succession of identical symbols preceded and followed by different or no symbols. The analysis is based upon the order and not the frequency of the data items. The sampling distribution of r is known and a table is available with critical values.

Let n_1 = the number of data items of one kind, n_2 = the number of data items of the other kind, $N = n_1 + n_2$ total number of data items, and r is the number of runs. For example, n_1 could be the number of heads and n_2 the number of tails, or n_1 could be the number of pluses and n_2 the number of minuses. To use the test, we observe the sample in the sequence they occur and determine r.

There are two cases to consider:

1) If n_1 and n_2 are both less than or equal to 20, we use the technique of determining r and use the table for critical values.

2) If either n_1 or n_2 is greater than 20, we cannot use the table. However, the sampling distribution is approximately normal, with

$$z = \frac{r - \mu_r}{\sigma_r} = \frac{r - \left(\frac{2n_1 n_2}{n_1+n_2} + 1\right)}{\sqrt{\frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1+n_2)^2 (n_1+n_2 - 1)}}}$$

Under the null hypothesis, z is approximately normally distributed, N(0,1). For critical values, use the normal curve table.

Example

Suppose we desire to know if a line of 36 people at a theater is randomly arranged. The order is as follows with runs indicated by underline.

M F M F MMM FF M F M F
M F MMMM F M F M F MM
FFF M F M F M F M

Let M = 0 and F = 1 for input.

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS104AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Suppose we desire to know if a line of 36 people at a theater is randomly arranged. The order is as follows with runs indicated by underline.

M F M F MMM FF M F M F
M F MMMM F M F M F MM
FFF M F M F M F M

Let M = 0 and F = 1 for input.

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION TOTALS KNOWN (Y OR N) ?_	6. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section IV. If 'N', go to the next step.
7. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	7. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
8. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	8. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 10.
9. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F040 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	9. Mount a scratch cassette and touch RETURN(EXEC).

Example

Suppose we desire to know if a line of 36 people at a theater is randomly arranged. The order is as follows with runs indicated by underline.

M F M F MMM FF M F M F
M F MMMM F M F M F MM
FFF M F M F M F M

Let M = 0 and F = 1 for input.

DISPLAYS	INSTRUCTIONS
10. INPUT PARAMETER ENTER SAMPLE SIZE ?_	10. Sample size = 36, touch RETURN(EXEC).
11. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?-	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 10. NOTE: The parameter is displayed for verification.
12. DATA INPUT FOR OBSERVATION #1 ENTER OBSERVATION VALUE (0/1) ?_	12. Observation value = 0, touch RETURN(EXEC).
13. DATA INPUT FOR OBSERVATION #2 ENTER OBSERVATION VALUE (0/1) ?_	13. Observation value = 1, touch RETURN(EXEC).

Enter all items in the example.

DISPLAYS	INSTRUCTIONS
14. CORRECTION ROUTINE FOR ITEMS #1-32 IS DATA OK (Y OR N) ?-	14. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The observation values are displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, type 'Y' and touch RETURN(EXEC).

Example

Suppose we desire to know if a line of 36 people at a theater is randomly arranged. The order is as follows with runs indicated by underline.

M F M F MMM FFM F M F
MF MMMM F M F M F MM
FFF M F M F M F M

Let M = 0 and F = 1 for input.

DISPLAYS	INSTRUCTIONS
15. CORRECTION ROUTINE FOR ITEMS #33-36 IS DATA OK (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.
16. REMOVE AND LABEL VOL 1 OF FILE NPS1F040 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	16. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 8 was answered negatively, ignore this step and go to step 17.
17. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	17. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 21.
18. ENTER OUTPUT DEVICE TYPE SYMBOL ?__ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	18. Enter device type symbol and touch RETURN(EXEC).
19. MOUNT VOL 1 OF FILE NPS1F040 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	19. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 8 was answered negatively, ignore this step and go to step 20b.

Example

Suppose we desire to know if a line of 36 people at a theater is randomly arranged. The order is as follows with runs indicated by underline.

M F M F MMM FF M F M F
M F MMMM F M F M F MM
FFF M F M F M F M

Let M = 0 and F = 1 for input.

DISPLAYS	INSTRUCTIONS
20a. READING DATA RECORD	20a. The system now is reading the data record.
b. EXECUTING PROGRAM	b. The system now is performing the One-Sample Ouns Test. NOTE: If one of the output printers was selected, the message PRINTING RESULTS is displayed.
21. STOP END OF PROGRAM :_	21. The test results are displayed for verification.
	22. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC) and go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to section II. If 'N', go to step 18.

SECTION II
ONE TAPE DRIVE CORRECTION

A. MOUNT VOL 1 OF FILE NPS1F040 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).

Example

Suppose we desire to know if a line of 36 people at a theater is randomly arranged. The order is as follows with runs indicated by underline.

M F M F MMM FF M F M F
M F MMMM F M F M F MM
FFF M F M F M F M

Let M = 0 and F = 1 for input.

DISPLAYS	INSTRUCTIONS
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F040 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. After mounting a scratch cassette, touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR ITEMS #1-32 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 16. If 'N', go to Section III.

NOTE:

The observation items are displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, type 'Y' and touch RETURN (EXEC).

SECTION III
DATA CORRECTION

A. CORRECTION ROUTINE FOR ITEMS #1-32. ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the item # of incorrect data and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR ITEMS #1-32 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC).

NOTE:

Follow steps A and B for all items.

Example

Suppose we desire to know if a line of 36 people at a theater is randomly arranged. The order is as follows with runs indicated by underline.

M F M F MMM FFM F M F
M FMMMM F M F M F MM
FFF M F M F M F M

Let M = 0 and F = 1 for input.

DISPLAYS	INSTRUCTIONS
	If branching from either step 14 or step 15, one of those steps reappears. Follow the appropriate operating instructions. If branching from Section II, step C, that step reappears. Follow the appropriate operating instructions.

SECTION IV
TOTALS KNOWN

A. INPUT TOTALS TER N('0') ?_	A. N('0') = 20, touch RETURN(EXEC).
B. INPUT TOTALS ENTER N('1') ?_	B. N('1') = 16, touch RETURN(EXEC).
C. INPUT TOTALS ENTER # OF RUNS ?_	C. The number of runs = 27, touch RETURN(EXEC).
D. INPUT TOTALS INFORMATION OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 21. If 'N', go to step A (Section IV).

Sample Output

```
THE ONE-SAMPLE RUNS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SIZE OF SAMPLE =  36


INPUT DATA

 0              1              0              1              0
 0              0              1              1              0
 1              0              1              0              1
 0              0              0              0              1
 0              1              0              1              0
 0              1              1              1              0
 1              0              1              0              1
 0

N('0') =  20
N('1') =  16
# RUNS =  27


END OF PROGRAM
```

CHAPTER VII THE MCNEMAR TEST FOR THE SIGNIFICANCE OF CHANGES

PROGRAM ABSTRACT

The program helps test a "before and after" treatment's effectiveness. One or both samples are measured on a nominal scale.

PROGRAM DESCRIPTION

The two-sample test in statistics is used to determine if two treatments are different or if one is better than the other. However, when comparing two groups, the significant differences may not be due to just the variables in the two groups but to variables outside the groups which effect the results. One method to overcome this outside influence is to use two related samples where the data values are paired, one from one sample and one from the other. It is preferable to use one subject placed under both treatments than to try to match subjects from each treatment to get a pair, because in matching, all the relevant variables in determining the match are not always taken into consideration. The parametric test usually used is the t-test which takes the difference between the paired data samples as the sample values. The sample is assumed to be drawn from a population that is normally and independently distributed and measured on an interval scale. But in many instances, these conditions cannot be met and the t-test is inapplicable. A nonparametric test which we can use is the McNemar Test for the Significance of Changes.

The McNemar Test is particularly useful in testing a situation of "before and after" to determine the effectiveness of a particular treatment. The scores are from a nominal or ordinal scale with the paired data values originating from two treatments on the same subject. To test the significance of any changes, the responses are accumulated in a two by two frequency table. The signs + and - are used to indicate the different responses. The table has the following look:

		AFTER	
		-	+
BEFORE	+	A	B
	-	C	D

If there has been a change in response from the subject, cells A and D would contain the frequency of changes, and A+D indicates the total number of subjects who change their response after undergoing the second treatment. Under the null hypothesis, we would expect that E = (A+D)/2 cases would change in one direction and an equal number would change in the other direction in their responses. Using the formula and substituting accordingly, we can generate the following formula:

$$X^2 = \frac{(A-D)^2}{A+D} \qquad \text{with d.f.} = 1$$

However, because the χ^2 is a continuous distribution and approximates a discrete one, it is necessary to add a correction for continuity and our formula is:

$$\chi^2 = \frac{(|A-D| - 1)^2}{A+D} \quad \text{with d.f.} = 1$$

If (A+D)/2 is less than 5, we use the Binomial Test instead of the McNemar Test. The value N is then (A+D), and x is the minimum (A,D). (P=Q=5.) For critical values, use the values found in the table for χ^2.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 160 of the program. By changing Statement 160, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

As it is sold, the program contains the following maximum parameters:

X = 254, where X = min (A,D).

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of X:

   $X + 1 \leq$ the number of variables available.

2. Select the appropriate value of X for your system from the following table:

CAPACITY	4K	8K
X for System A	76	254

3. Insert System Tape #1 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS105AA", and touch RETURN(EXEC).

5. Key LIST 160, and touch RETURN(EXEC).
   The screen should display:

   ```
   160 DIM S(255):SELECT #110A
   ```

6. Rekey statement using the new maximum parameters:

   ```
   160 DIM S(X+1):SELECT #110A
   ```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS105AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Suppose the significance of change in behavior is desired in an experiment. The data frequencies are as follows in the table:

13	3
4	5

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS105AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC).

Example

Suppose the significance of change in behavior is desired in an experiment. The data frequencies are as follows in the table:

13	3
4	5

DISPLAYS	INSTRUCTIONS
	If 'Y', go to the next step. If 'N', go to step 2.
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT DATA ENTER FREQUENCY TABLE VALUE A ?_	6. A = 13, touch RETURN(EXEC).
7. INPUT DATA ENTER FREQUENCY TABLE VALUE D ?_	7. D = 5, touch RETURN(EXEC).
8. INPUT DATA INPUT DATA OK (Y OR N) ?_	8. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 6.
9. ENTER OUTPUT DEVICE SYMBOL ?__ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	9. Enter device type symbol and touch RETURN(EXEC).
10. EXECUTING PROGRAM	10. The system now is executing the McNemar Test for the Significance of Changes.

Example

Suppose the significance of change in behavior is desired in an experiment. The data frequencies are as follows in the table:

13	3
4	5

DISPLAYS	INSTRUCTIONS
	NOTE: If one of the output printers was selected, the message PRINTING RESULTS is displayed.
11. STOP END OF PROGRAM :_	11. The test results are displayed for verification.
	12. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC) and go to step 2.

Sample Output

```
 THE MCNEMAR TEST FOR THE SIGNIFICANCE OF CHANGES
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


A =  13
D =  5


CHI-SQUARE =  2.722222222222
      D.F. =  1


END OF PROGRAM
```

CHAPTER VIII THE SIGN TEST

PROGRAM ABSTRACT

Using the sign value rather than the difference value of the matched-pair, the program checks to see if the two conditions are different. The test variable has a continuous distribution. Data is measured from an ordinal scale at least.

PROGRAM DESCRIPTION

The two-sample test in statistics is used to determine if two treatments are different or if one is better than the other. However, when comparing two groups, the significant differences may not be due to just the variables in the two groups but to variables outside the groups which effect the results. One method to overcome this outside influence is to use two related samples where the data values are paired, one from one sample and one from the other. It is preferable to use one subject placed under both treatments than to try to match subjects from each treatment to get a pair, because in matching, all the relevant variables in determining the match are not always taken into consideration. The parametric test usually used is the t-test which takes the difference between the paired data samples as the sample values. The sample is assumed to be drawn from a population that is normally and independently distributed and measured on an interval scale. But in many instances, these conditions cannot be met and the t-test is inapplicable. A nonparametric test which we can use is the Sign Test.

The Sign Test indicates through its name what the test is about. It uses plus and minus signs rather than the data values themselves in the test. It is especially useful in testing to see if two conditions under study are different. It is necessary to assume that the variable under study has a continuous distribution. Again the sample values are match-paired. The null hypothesis under consideration is that the median is zero, or

$$H_0: p(A_i > B_i) = p(A_i < B_i) = \frac{1}{2}, \; i = 1, \ldots, N$$

where the data pairs are (A_i, B_i). If the difference between the data pair is zero, then that particular data pair is thrown out and not included in the analysis. Thus, we may have M data input pairs but the analysis is run on only N data pairs whose differences show a sign ($M \geq N$).

If N is 25 or smaller, we use the Binomial test instead of the Sign Test. The value x is the smaller number of signs and P=Q=1/2. If N is larger than 25, we use the normal approximation of the binomial distribution:

$$\mu_x = \frac{1}{2} N \qquad \sigma_x = \frac{1}{2} \sqrt{N}$$

$$z = \frac{x - \mu_x}{\sigma_x} = \frac{x - \frac{1}{2} N}{\frac{1}{2} \sqrt{N}} \qquad \text{with } N(0,1).$$

Again, a correction for continuity is necessary to make the approximation an excellent one:

$$z = \frac{(x \pm .5) - \frac{1}{2}N,}{\frac{1}{2}\sqrt{N}} \qquad \text{where } x + .5 \text{ IF } x < \frac{1}{2}N$$

$$x - .5 \text{ IF } x > \frac{1}{2}N$$

For significance values, use any Normal distribution table.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

M = 140, where M = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of M:

   $(2*M) \leq$ the number of variables available.

2. Select the appropriate value of M for your system from the following table:

CAPACITY	8K	12K
M for System A	140	255

3. Insert System Tape #1 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS106AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).
   The screen should display:

```
170 DIM X(140),Y(140):SELECT #110A
```

6. Rekey statement using the new maximum parameters:

```
170 DIM X(M),Y(M):SELECT #110A
```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS106AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use the System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Test the following two samples for difference.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	5	5	6	6	4	3	6	4	2	6	6	6	5	6	6	6	6
B	3	4	4	4	4	4	4	4	3	4	3	3	6	3	6	4	2

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN (EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS106AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?------------------	2. Enter project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?------------------	3. Enter user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

Example

Test the following two samples for difference.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	5	5	6	6	4	3	6	4	2	6	6	6	5	6	6	6	6
B	3	4	4	4	4	4	4	4	3	4	3	3	6	3	6	4	2

DISPLAYS	INSTRUCTIONS
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION TOTALS KNOWN (Y OR N) ?_	6. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section IV. If 'N', go to the next step.
7. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	7. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
8. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	8. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 10.
9. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F060 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	9. Mount a scratch cassette and touch RETURN(EXEC).
10. INPUT PARAMETER ENTER SAMPLE SIZE ?_	10. Sample size = 17, touch RETURN(EXEC).
11. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 10.

Example

Test the following two samples for difference.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	5	5	6	6	4	3	6	4	2	6	6	6	5	6	6	6	6
B	3	4	4	4	4	4	4	4	3	4	3	3	6	3	6	4	2

DISPLAYS	INSTRUCTIONS
	NOTE: The parameter is displayed for verification.
12. DATA INPUT FOR DATA PAIR #1 ENTER FIRST VALUE ?_	12. First value = 5, touch RETURN(EXEC).
13. DATA INPUT FOR DATA PAIR #1 ENTER SECOND VALUE ?_	13. Second value = 3, touch RETURN(EXEC).
14. CORRECTION ROUTINE FOR DATA PAIR #1 IS DATA OK (Y OR N) ?_	14. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 12. If 'N', go to Section III NOTE: The input data is displayed for verification.

Enter all items in the example.

DISPLAYS	INSTRUCTIONS
15. REMOVE AND LABEL VOL 1 OF FILE NPS1F060 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	15. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 8 was answered negatively, ignore this step and go to step 16.
16. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	16. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 20.

Example

Test the following two samples for difference.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	5	5	6	6	4	3	6	4	2	6	6	6	5	6	6	6	6
B	3	4	4	4	4	4	4	4	3	4	3	3	6	3	6	4	2

DISPLAYS	INSTRUCTIONS
17. ENTER OUTPUT DEVICE SYMBOL ?_ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	17. Enter an output device symbol and touch RETURN(EXEC).
18. MOUNT VOL 1 OF FILE NPS1F060 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	18. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 8 was answered negatively, ignore this step and go to step 19b.
19a. READING DATA RECORD	19a. The system now is reading the data.
b. EXECUTING PROGRAM	b. The system now is executing the Sign Test. NOTE: If one of the output printers was selected, the message PRINTING RESULTS is displayed.
20. STOP END OF PROGRAM :_	20. The test results are displayed for verification.
	21. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

Example

Test the following two samples for difference.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	5	5	6	6	4	3	6	4	2	6	6	6	5	6	6	6	6
B	3	4	4	4	4	4	4	4	3	4	3	3	6	3	6	4	2

DISPLAYS	INSTRUCTIONS

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 17.

SECTION II
ONE TAPE DRIVE CORRECTION

A. MOUNT VOL 1 OF FILE NPS1F060 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME NPS1F060-UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. ENTER PAIR # IN ERROR (0 IF END) ?_	C. Enter the pair number in error or 0 and touch RETURN(EXEC). If a pair number is entered, go to the next step. If '0' is entered, go to step 15.
D. CORRECTION ROUTINE FOR DATA PAIR #1 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Step C of Section II. If 'N', go to Section III. NOTE: The input data is displayed for verification.

Example

Test the following two samples for difference.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	5	5	6	6	4	3	6	4	2	6	6	6	5	6	6	6	6
B	3	4	4	4	4	4	4	4	3	4	3	3	6	3	6	4	2

DISPLAYS	INSTRUCTIONS

SECTION III
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR DATA PAIR #1 ENTER CORRECT FIRST VALUE ?_	A. Enter correct first value and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR DATA PAIR #1 ENTER CORRECT SECOND VALUE ?_	B. Enter correct second value and touch RETURN(EXEC). NOTE: Follow steps A and B for all data pairs. If branching from step 14, that step reappears. Follow the appropriate operating instructions. If branching from Section II, step D, that step reappears. Follow the appropriate operating instructions.

SECTION IV
TOTALS KNOWN

DISPLAYS	INSTRUCTIONS
A. INPUT TOTALS ENTER N('+') ?_	A. N('+') = 67, touch RETURN(EXEC).
B. INPUT TOTALS ENTER N('-') ?_	B. N('-') = 33, touch RETURN (EXEC).
C. INPUT TOTALS INFORMATION OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 19b. If 'N', go to step A.

Example

Test the following two samples for difference.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	5	5	6	6	4	3	6	4	2	6	6	6	5	6	6	6	6
B	3	4	4	4	4	4	4	4	3	4	3	3	6	3	6	4	2

DISPLAYS	INSTRUCTIONS
	NOTE: The totals are displayed for verification.

Sample Output

```
THE SIGN TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

SIZE OF SAMPLE =  17

INPUT DATA:     I          X(I)        Y(I)        SIGN
                1          5           3           1
                2          5           4           1
                3          6           4           1
                4          6           4           1
                5          4           4           0
                6          3           4          -1
                7          6           4           1
                8          4           4           0
                9          2           3          -1
               10          6           4           1
               11          6           3           1
               12          6           3           1
               13          5           6          -1
               14          6           3           1
               15          6           6           0
               16          6           4           1
               17          6           2           1
```

```
THE SIGN TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SIZE OF SAMPLE =  17


PROBABILITIES:  I                P(I)
                 0                6.10351562E-05
                 1                8.54492187E-04
                 2                5.55419921E-03
                 3                2.22167968E-02


N('+') =  11
N('-') =  3
     N =  14


       P( 3 ) =  2.22167968E-02
P(X .LE.  3 ) =  2.86865234E-02


END OF PROGRAM
```

CHAPTER IX THE WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST

PROGRAM ABSTRACT

For refined ordinal measurements from a continuous population, the program determines if there is a difference between samples. However, it takes into account the relative magnitude as well as the direction of the differences.

PROGRAM DESCRIPTION

The two-sample test in statistics is used to determine if two treatments are different or if one is better than the other. However, when comparing two groups, the significant differences may not be due to just the variables in the two groups but to variables outside the groups which effect the results. One method to overcome this outside influence is to use two related samples where the data values are paired, one from one sample and one from the other. It is preferable to use one subject placed under both treatments than to try to match subjects from each treatment to get a pair, because in matching, all the relevant variables in determining the match are not always taken into consideration. The parametric test usually used is the t-test which takes the difference between the paired data samples as the sample values. The sample is assumed to be drawn from a population that is normally and independently distributed and measured on an interval scale. But in many instances, these conditions cannot be met and the t-test is inapplicable. A nonparametric test which we can use is the Wilcoxon Matched-Pairs Signed-Ranks Test.

Where the Sign Test used the direction of the paired difference, the Wilcoxon Test also considers the relative magnitude along with the direction of the difference value. Thus, a larger difference value has more weight in the analysis than a smaller difference. This is a most useful test in behavioral science. Again, if the difference of a data pair is zero, the data pair is thrown out and not used in the analysis. Thus, we may have M data input pairs, but the analysis is run on only N data pairs whose differences show a sign ($M \geq N$). The test variable has a continuous distribution.

The procedure to use the test is to compute the differences between the data pairs. Then, we rank the differences without respect to sign ($|d_i|$). Next, we affix to each rank the sign of the difference which it represents. If there are tied values or differences, the ties are broken in the program by assigning average ranks. Determine T(+) as the sum of the positive ranks and T(-) as the sum of the negative ranks. Then, T is the minimum of T(+) and T(-).

If N is 25 or less, we go to a table prepared for the Wilcoxon Test for our critical values. If N is larger than 25, we use the normal approximation:

$$\mu_T = \frac{N(N+1)}{4} \qquad \sigma_T = \sqrt{\frac{N(N+1)\ (2N+1)}{24}}$$

$$z = \frac{T - \mu_T}{\sigma_T} \qquad \text{With } N\ (0,1)$$

For critical values, use the table for the normal distribution.

However, the normal approximation is such an excellent one that it is even useful in determining values for small samples. Therefore, the program is written to determine the z-value for all values of N, large and small.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

M = 147, where M = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of M:

   $(2*M) \leq$ the number of variables available.

2. Select the appropriate value of M for your system from the following table:

CAPACITY	8K	12K
M for System A	147	255

3. Insert System Tape #1 into Unit 1 (on the Console), close the door and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS107AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).
   The screen should display:

   ```
   170 DIM X(147),Y(147):SELECT #110A
   ```

6. Rekey statement using the new maximum parameters:

   ```
   170 DIM X(M),Y(M):SELECT #110A
   ```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS107AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Given a behavioral study, we want to test the effect for two related samples.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	12	9	11	6	15	5	6	8	8	15	11	8	5	13
B	11	10	10	4	12	1	10	3	4	10	5	1	5	20

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow all operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS107AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

Example

Given a behavioral study, we want to test the effect for two related samples.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	12	9	11	6	15	5	6	8	8	15	11	8	5	13
B	11	10	10	4	12	1	10	3	4	10	5	1	5	20

DISPLAYS	INSTRUCTIONS
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F070 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch tape and touch RETURN(EXEC).
9. INPUT PARAMETER ENTER SAMPLE SIZE ?_	9. Sample size = 14, touch RETURN(EXEC).
10. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
	NOTE: The parameter is displayed for verification.

Example

Given a behavioral study, we want to test the effect for two related samples.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	12	9	11	6	15	5	6	8	8	15	11	8	5	13
B	11	10	10	4	12	1	10	3	4	10	5	1	5	20

DISPLAYS	INSTRUCTIONS
11. DATA INPUT FOR DATA PAIR #1 ENTER FIRST VALUE ?_	11. First value = 12, touch RETURN(EXEC).
12. DATA INPUT FOR DATA PAIR #1 ENTER SECOND VALUE ?_	12. Second value = 11, touch RETURN(EXEC).
13. CORRECTION ROUTINE FOR DATA PAIR #1 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section III. NOTE: The input data is displayed for verification.

Enter all items in the example.

DISPLAYS	INSTRUCTIONS
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F070 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 15.
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?__	16. Enter an output device symbol and touch RETURN(EXEC).

Example

Given a behavioral study, we want to test the effect for two related samples.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	12	9	11	6	15	5	6	8	8	15	11	8	5	13
B	11	10	10	4	12	1	10	3	4	10	5	1	5	20

DISPLAYS	INSTRUCTIONS
FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	
17. MOUNT VOL 1 OF FILE NPS1F070 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 18b.
18a. READING DATA RECORD	18a. The system now is reading the data.
b. EXECUTING PROGRAM	b. The system now is executing the Wilcoxon Matched-pairs Signed Ranks Test. NOTE: If one of the output devices was selected, the message PRINTING RESULTS is displayed.
19. STOP END OF PROGRAM :_	19. The test results are displayed for verification.
	20. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC).

Example

Given a behavioral study, we want to test the effect for two related samples.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	12	9	11	6	15	5	6	8	8	15	11	8	5	13
B	11	10	10	4	12	1	10	3	4	10	5	1	5	20

DISPLAYS	INSTRUCTIONS
	If 'Y', go to Section II. If 'N', go to step 16.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F070 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F070 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. ENTER PAIR # IN ERROR (0 IF END) ?_	C. Enter the pair number in error or 0 and touch RETURN(EXEC). If a pair number is entered, go to the next step. If 0 is entered, go to step 14.
D. CORRECTION ROUTINE FOR DATA PAIR #1 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step C of Section II. If 'N', go to Section III. NOTE: The input data is displayed for verification.

SECTION III
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR DATA PAIR #1 ENTER CORRECT FIRST VALUE ?_	A. Enter correct first value and touch RETURN(EXEC).

Example

Given a behavioral study, we want to test the effect for two related samples.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	12	9	11	6	15	5	6	8	8	15	11	8	5	13
B	11	10	10	4	12	1	10	3	4	10	5	1	5	20

DISPLAYS	INSTRUCTIONS
B. CORRECTION ROUTINE FOR DATA PAIR #1 ENTER CORRECT SECOND VALUE ?_	B. Enter correct second value and touch RETURN(EXEC).

NOTE:

Follow steps A and B for all data pairs.

If branching from step 13, that step reappears. Follow the appropriate operating instructions.

If branching from Section II, step D, that step reappears. Follow the appropriate operating instructions.

Sample Output

```
THE WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SIZE OF SAMPLE =  14


INPUT DATA:      I          A          B          D
                 1          12         11         1
                 2          9          10        -1
                 3          11         10         1
                 4          6          4          2
                 5          15         12         3
                 6          5          1          4
                 7          6          10        -4
                 8          8          3          5
                 9          8          4          4
                 10         15         10         5
                 11         11         5          6
                 12         8          1          7
                 13         5          5          0
                 14         13         20        -7
```

```
THE WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SIZE OF SAMPLE =  14


SIGNED RANKS:

 2                 -2                 2                 4                 5
 7                 -7                 7                 9.5               9.5
 11                 12.5             -12.5


T('+') =  69.5
T('-') =  21.5
     T =  21.5
     N =  13


   Z = -1.677255738785
P(Z) =  4.67462418E-02


END OF PROGRAM
```

CHAPTER X THE WALSH TEST

PROGRAM ABSTRACT

The program tests for difference if the two sample populations are symmetrical and continuous. Measurement is on an interval scale.

PROGRAM DESCRIPTION

The two-sample test is used in statistics to determine if two treatments are different or if one is better than the other. However, when comparing two groups, the significant differences may not be due to just the variables in the two groups but to variables outside the groups which effect the results. One method to overcome this outside influence is to use two related samples where the data values are paired, one from one sample and one from the other. It is preferable to use one subject placed under both treatments than to try to match subjects from each treatment to get a pair, because in matching, all the relevant variables in determining the match are not always taken into consideration. The parametric test usually used is the t-test which takes the difference between the paired data samples as the sample values. The sample is assumed to be drawn from a population that is normally and independently distributed and measured on an interval scale. But in many instances, these conditions cannot be met and the t-test is inapplicable. A nonparametric test which we can use is the Walsh Test.

If it can be assumed that the two related samples are drawn from symmetrical and continuous populations, then the Walsh Test is an extremely powerful test to use. This assumes then that if the populations are symmetrical, then the mean is equal to the median and is a good measure for central tendency. The samples are assumed to be measured in at least an interval scale.

The procedure to follow is to compute the differences in the pairs and then rank the differences. Unlike the Wilcoxon test, the sign of the differences is taken into account when ranking. Then going to a special table generated for finding critical values for the Walsh test, we use the ranked differences in the actual value computation. The table is self-explanatory.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

M = 166, where M = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of M:

   $(2*M) \leq$ the number of variables available.

2. Select the appropriate value of M for your system from the following table:

CAPACITY	8K	12K
M for System A	166	255

3. Insert the System Tape #1 into Unit 1 (on the Console), close the door and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS108AA", and touch RETURN(EXEC).

5. Key LIST 170 and touch RETURN(EXEC).
   The screen should display:

   170 DIM X(166),Y(166):SELECT #110A:

6. Rekey statement using the new maximum parameters:

   170 DIM X(M),Y(M):SELECT #110A.

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS108AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Test for difference if the two samples are from symmetrical populations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	7	6	5	7	4	6	4	4	6	6	5	3	7	5	3
B	4	4	2	5	5	4	5	3	3	6	6	4	4	6	2

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS108AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------	3. Enter user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

Example

Test for difference if the two samples are from symmetrical populations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	7	6	5	7	4	6	4	4	6	6	5	3	7	5	3
B	4	4	2	5	5	4	5	3	3	6	6	4	4	6	2

DISPLAYS	INSTRUCTIONS
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F080 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETER ENTER SAMPLE SIZE ?_	9. Sample size = 15, touch RETURN(EXEC).
10. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9. NOTE: The parameter is displayed for verification.

Example

Test for difference if the two samples are from symmetrical populations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	7	6	5	7	4	6	4	4	6	6	5	3	7	5	3
B	4	4	2	5	5	4	5	3	3	6	6	4	4	6	2

DISPLAYS	INSTRUCTIONS
11. DATA INPUT FOR DATA PAIR #1 ENTER FIRST VALUE ?_	11. First value = 7, touch RETURN(EXEC).
12. DATA INPUT FOR DATA PAIR #1 ENTER SECOND VALUE ?_	12. Second value = 4, touch RETURN(EXEC).
13. CORRECTION ROUTINE FOR DATA PAIR #1 IS DATA OK (Y OR N) ?-_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section III. NOTE: The input data is displayed for verification.

Enter all items in example.

DISPLAYS	INSTRUCTIONS
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F080 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 15.
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?-_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 21.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?--_	16. Enter an output device symbol and touch RETURN(EXEC).

Example

Test for difference if the two samples are from symmetrical populations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	7	6	5	7	4	6	4	4	6	6	5	3	7	5	3
B	4	4	2	5	5	4	5	3	3	6	6	4	4	6	2

DISPLAYS	INSTRUCTIONS
FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	
17. MOUNT VOL 1 OF FILE NPS1F080 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If Step 7 was answered negatively, ignore this step and go to step 18b.
18a. READING DATA RECORD	18a. The system now is reading the data.
b. EXECUTING PROGRAM	b. The system now is executing the Walsh Test.
c. SORTING DATA	c. The system now is sorting data.
19. COMPUTE CRITICAL VALUES '(D(I) + D(J))/2' ENTER VALUE FOR I (0 IF END) ?_	19. I = 1 or 0 if end, touch RETURN(EXEC).
20. COMPUTE CRITICAL VALUES '(D(I) + D(J))/2' ENTER VALUE FOR J ?_	20. J = 2, touch RETURN(EXEC). NOTE: After executing step 20, the critical value is displayed for verification. Go to step 19 or, if end, go to step 21 after entering I=0 at step 19.
21. STOP END OF PROGRAM :_	21. The test results are displayed for verification.
	22. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC), and go to step 2.

Example

Test for difference if the two samples are from symmetrical populations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	7	6	5	7	4	6	4	4	6	6	5	3	7	5	3
B	4	4	2	5	5	4	5	3	3	6	6	4	4	6	2

DISPLAYS	INSTRUCTIONS

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 16.

SECTION II
ONE TAPE DRIVE CORRECTION

A. MOUNT VOL 1 OF FILE NPS1F080 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F080 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. ENTER PAIR # IN ERROR (0 IF END) ?_	C. Enter the pair number in error or 0 and touch RETURN(EXEC). If a pair number in error is entered, go to the next step. If '0' go to step 14.
D. CORRECTION ROUTINE FOR DATA PAIR #1 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step C of Section II. If 'N', go to Section III. NOTE: The input data is displayed for verification.

Example

Test for difference if the two samples are from symmetrical populations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	7	6	5	7	4	6	4	4	6	6	5	3	7	5	3
B	4	4	2	5	5	4	5	3	3	6	6	4	4	6	2

DISPLAYS	INSTRUCTIONS

SECTION III
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR DATA PAIR #1 ENTER CORRECT FIRST VALUE ?_	A. Enter the correct first value and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR DATA PAIR #1 ENTER CORRECT SECOND VALUE ?_	B. Enter the correct second value and touch RETURN(EXEC).

NOTE:

Follow steps A and B for all data pairs.

If branching from step 13, that step reappears. Follow the appropriate operating instructions.

If branching from Section II, step D, that step reappears. Follow the appropriate operating instructions.

Sample Output

THE WALSH TEST
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

SIZE OF SAMPLE = 15

INPUT DATA:

I	A	B	D
1	7	4	3
2	6	4	2
3	5	2	3
4	7	5	2
5	4	5	-1
6	6	4	2
7	4	5	-1
8	4	3	1
9	6	3	3
10	6	6	0
11	5	6	-1
12	3	4	-1
13	7	4	3
14	5	6	-1
15	3	2	1

THE WALSH TEST
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

SIZE OF SAMPLE = 15

SORTED DIFFERENCE VALUES:

-1	-1	-1	-1	-1
0	1	1	2	2
2	3	3	3	3

CRITICAL VALUES:

I	J	VALUE
1	2	-1

END OF PROGRAM

CHAPTER XI THE FISHER EXACT PROBABILITY TEST

PROGRAM ABSTRACT

With two independent samples, the program helps determine if the differences in the samples are convincing proof that there is a difference in the two treatments applied to them. The data is discrete and the samples small. The data can be broken into two mutually exclusive classes in a (2x2) table.

PROGRAM DESCRIPTION

In the case of two independent samples, we can test to determine if the differences in the samples are convincing proof that there is a difference in the two processes applied to them. The samples may be of unequal size. The data that constitutes the two samples may be either drawn randomly from two populations or arise from random assignment of two treatments to the members of some arbitrary sample. The usual parametric test is to apply a t-test to the means of the two groups. This requires that the data values are independent and drawn from normal populations with equal variances. Also the scores are measured on at least an interval scale. Many times, these assumptions cannot be realistically met. A nonparametric test which can be used is the Fisher Exact Probability Test.

The Fisher Test is an extremely useful nonparametric technique for analyzing discrete data when both samples are small. It is used when the data from both groups all fall in one or the other of two mutually exclusive classes. These are recorded as frequencies in a 2x2 contingency table. For example, Group X and Group Y broken into males and females:

	M	F	
X	A	B	A+B
Y	C	D	C+D
	A+C	B+D	N

The exact probability value can be determined by the hypergeometric distribution:

$$p = \frac{\binom{A+C}{A}\binom{B+D}{B}}{\binom{N}{A+B}}$$

$$= \frac{(A+B)!\,(C+D)!\,(A+C)!\,(B+D)!}{N!\,A!\,B!\,C!\,D!}$$

This is actually only the ratio of the product of the factorials of the four marginal totals to the product of the cell frequencies multiplied by N factorial. However, it is simple to compute the exact probability with at least one frequency value being zero. What if we desire to compute the probability of an occurrence or one even more extreme? We then would sum the probability of occurrence with the probability of the more extreme one(s).

Although Fisher recommends the test for all types of dichotomous data, others question this. However, Tocher (1950) has come up with a slight modification which makes the test one of the most powerful one-tailed test for a 2x2 table of data. The formula for this modification is:

$$\frac{\alpha - p(\text{more extreme cases})}{p(\text{observed case taken alone})}$$

Example

Let us determine the significance of difference given the following table:

	X	Y
I	5	6
II	2	3

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS109AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?-------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

Example

Let us determine the significance of difference given the following table:

	X	Y
I	5	6
II	2	3

DISPLAYS	INSTRUCTIONS
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT DATA ENTER FREQUENCY VALUE OF A ?_	6. Frequency value of A = 5, touch RETURN(EXEC).
7. INPUT DATA ENTER FREQUENCY VALUE OF B ?_	7. Frequency value of B = 6, touch RETURN(EXEC).
8. INPUT DATA ENTER FREQUENCY VALUE OF C ?_	8. Frequency value of C = 2, touch RETURN(EXEC).
9. INPUT DATA ENTER FREQUENCY VALUE OF D ?_	9. Frequency value of D = 3, touch RETURN(EXEC).
10. INPUT DATA ENTER OBSERVED LEVEL OF SIGNIFICANCE - ALPHA (-1 IF NONE) ?_	10. Alpha = .05, touch RETURN(EXEC).
11. INPUT DATA INPUT DATA OK (Y OR N) ?_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 6. NOTE: The input data is displayed for verification.

Example

Let us determine the significance of difference given the following table:

	X	Y
I	5	6
II	2	3

DISPLAYS	INSTRUCTIONS
12. ENTER OUTPUT DEVICE TYPE SYMBOL ?--	12. Enter an output device symbol and touch RETURN(EXEC).
FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	
13. EXECUTING PROGRAM	13. The system now is performing the Fisher Exact Probability Test.
14. STOP END OF PROGRAM :_	14. The test results are displayed for verification.
	15. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

Sample Output

```
THE FISHER EXACT PROBABILITY TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

INPUTTED CONTINGENCY TABLE:

                  A =  5            B =  6
                  C =  2            D =  3

ALPHA = 0.0500

INTERMEDIATE CONTINGENCY TABLES USED

A                B                C                D                P(I)
 2                5                3                6                .4038461538462
 1                6                4                5                .2019230769231
 0                7                5                4                2.88461538E-02


       P =  .6346153846154
TOCHER P = -.4476190476189

END OF PROGRAM
```

CHAPTER XII THE CHI-SQUARE TEST FOR TWO INDEPENDENT SAMPLES

PROGRAM ABSTRACT

The program tests to see if the difference in two processes is due to some characteristic and the data falls in several discrete categories. The data usually comes from a nominal or stronger scale.

PROGRAM DESCRIPTION

In the case of two independent samples, we can test to determine if the differences in the samples are convincing proof that there is a difference in the two processes applied to them. The samples may be of unequal size. The data that constitutes the two samples may be either drawn randomly from two populations or arise from random assignment of two treatments to the members of some arbitrary sample. The usual parametric test is to apply a t-test to the means of the two groups. This requires that the data values are independent and drawn from normal populations with equal variances. Also the scores are measured on at least an interval scale. Many times, these assumptions cannot be realistically met. A nonparametric test which can be used is the χ^2 Test for Two Independent Samples.

The χ^2 Test is used when the data consists of frequencies in discrete categories. The hypothesis under test is that the two groups differ with respect to some characteristic and therefore with respect to the relative frequency, each sample falls in each category. The formula used to test the H_0 is:

$$\chi^2 = \sum_{i=1}^{2} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where O_{ij} = Observed number of cases.

E_{ij} = Expected number of cases.

k = Number of categories, groups.

The value is distributed approximately as Chi-square with (k-1) degrees of freedom. If k=2, then we have a 2x2 table and we use the following formula:

$$\chi^2 = \frac{N\left(|AD-BC| - N/2\right)^2}{(A+B)\,(C+D)\,(A+C)\,(B+D)} \quad \text{d.f.} = 1$$

Although it is recommended that the Fisher Test be used for k less than 20 and in the case of k between 20 and 40 with the smallest frequency less than five, the program will use a χ^2 Test for these situations when there is a 2x2 table. The program is written to take all cases and use the χ^2 Test.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

N = 169, where N = # of categories.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of N:

   $(2*N) \leq$ the number of variables available.

2. Select the appropriate value of N for your system from the following table:

CAPACITY	8K	12K
N for System A	169	255

3. Insert System Tape #1 into Unit 1 (on the Console), close the door and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS110AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).
   The screen should display:

   ```
   170 DIM X(169),Y(169):SELECT #110A
   ```

6. Rekey statement using the new maximum parameters:

   ```
   170 DIM X(N),Y(N):SELECT #110A
   ```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS110AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Let us determine significance of difference given the following table of data:

	1	2	3	4	5	6	7
O_1	19	7	40	16	23	10	8
O_2	24	6	32	5	15	5	14

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter 1. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS110AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?-------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Let us determine significance of difference given the following table of data:

	1	2	3	4	5	6	7
O_1	19	7	40	16	23	10	8
O_2	24	6	32	5	15	5	14

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS DATA FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F100 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETER ENTER # OF CATEGORIES ?_	9. The number of categories = 7, touch RETURN(EXEC).
10. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC).

Example

Let us determine significance of difference given the following table of data:

	1	2	3	4	5	6	7
O_1	19	7	40	16	23	10	8
O_2	24	6	32	5	15	5	14

DISPLAYS	INSTRUCTIONS
	If 'Y', go to the next step. If 'N', go to step 9. NOTE: The parameter is displayed for verification.
11. DATA INPUT FOR CATEGORY #1 ENTER VALUE FOR (1,J) ?_	11. (1,J) = 19, touch RETURN(EXEC).
12. DATA INPUT FOR CATEGORY #1 ENTER VALUE FOR (2,J) ?_	12. (2,J) = 24, touch RETURN (EXEC).
13. CORRECTION ROUTINE FOR CATEGORY #1 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section III. NOTE: The input data is displayed for verification.

Enter all items in the example.

DISPLAYS	INSTRUCTIONS
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F100 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 15.

Example

Let us determine significance of difference given the following table of data:

	1	2	3	4	5	6	7
O_1	19	7	40	16	23	10	8
O_2	24	6	32	5	15	5	14

DISPLAYS	INSTRUCTIONS
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?-- FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	16. Enter an output device symbol and touch RETURN(EXEC).
17. MOUNT VOL 1 OF FILE NPS1F100 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 18b.
18a. READING DATA RECORD	18a. The system now is reading the data record.
b. EXECUTING PROGRAM	b. The system is now executing the Chi-Square Test for Two Independent Samples. NOTE: If one of the output printers was selected, the message PRINTING RESULTS is displayed.
19. STOP END OF PROGRAM :_	19. The test results are displayed for verification.

Example

Let us determine significance of difference given the following table of data:

	1	2	3	4	5	6	7
O_1	19	7	40	16	23	10	8
O_2	24	6	32	5	15	5	14

DISPLAYS	INSTRUCTIONS
	20. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y' go to Section II If 'N' go to step 16

SECTION II
ONE TAPE DRIVE CORRECTION

A. MOUNT VOL 1 OF FILE NPS1F100 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F100 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. ENTER CATEGORY # IN ERROR (0 IF END) ?_	C. Enter the number of the category in error or 0, and touch RETURN(EXEC). If the category number in error is entered, go to the next step. If '0', go to step 14.

Example

Let us determine significance of difference given the following table of data:

	1	2	3	4	5	6	7
O_1	19	7	40	16	23	10	8
O_2	24	6	32	5	15	5	14

DISPLAYS	INSTRUCTIONS
D. CORRECTION ROUTINE FOR CATEGORY #1 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step C of Section II. If 'N', go to Section III.

> NOTE:
>
> The input data is displayed for verification.

SECTION III
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR CATEGORY #1 ENTER CORRECT FIRST VALUE ?_	A. Enter the correct first value and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR CATEGORY #1 ENTER CORRECT SECOND VALUE ?_	B. Enter the correct second value and touch RETURN(EXEC).

> NOTE:
>
> Follow steps A and B for all categories.
>
> If branching from step 13, that step reappears. Follow the appropriate operating instructions.
>
> If branching from Section II, step D, that step reappears. Follow the appropriate operating instructions.

Sample Output

```
 THE CHI-SQUARE TEST FOR TWO INDEPENDENT SAMPLES
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF CATEGORIES =  7


INPUT DATA:        J               O(1,J)          O(2,J)
                    1               19              24
                    2               7               6
                    3               40              32
                    4               16              5
                    5               23              15
                    6               10              5
                    7               8               14


THE CHI-SQUARE TEST FOR TWO INDEPENDENT SAMPLES
PROJECT  WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

# OF CATEGORIES =  7

I          J          O(I,J)     E(I,J)             X(I,J)
 1          1          19          23.61160714286   .9806977081791
 2          1          24          19.38839285714   1.096889288179
 1          2          7           7.138392857143   2.68303850E-03
 2          2          6           5.861607142857   3.26746273E-03
 1          3          40          39.53571428571   5.45231642E-03
 2          3          32          32.46428571429   6.63994970E-03
 1          4          16          11.53125         1.731792005377
 2          4          5           9.46875          2.10901402635
 1          5          23          20.86607142857   .2182323186034
 2          5          15          17.13392857143   .2657680711704
 1          6          10          8.236607142857   .3775285520685
 2          6          5           6.763392857143   .4597624941032
 1          7          8           12.08035714286   1.378213757765
 2          7          14          9.919642857143   1.678418734704


CHI-SQUARE =  10.23435972387
      D.F.  =  6


END OF PROGRAM
```

CHAPTER XIII THE MEDIAN TEST

PROGRAM ABSTRACT

The program tests to see if the two independent samples differ in central tendencies, or in other words, are drawn from populations with the same median. The data is from at least an ordinal scale.

PROGRAM DESCRIPTION

In the case of two independent samples, we can test to determine if the differences in the samples are convincing proof that there is a difference in the two processes applied to them. The samples may be of unequal size. The data that constitutes the two samples may be either drawn randomly from two populations or arise from random assignment of two treatments to the members of some arbitrary sample. The usual parametric test is to apply a t-test to the means of the two groups. This requires that the data values are independent and drawn from normal populations with equal variances. Also the scores are measured on at least an interval scale. Many times, these assumptions cannot be realistically met. A nonparametric test which can be used is the Median Test.

The Median Test is a technique for testing whether two independent samples differ in central tendencies, or, in other words, are drawn from populations with the same median. The data is from at least an ordinal scale. To perform the test, we combine the two samples and determine the median value. Then we dichotomize both samples at the median and create a 2x2 table.

	X	Y	
above	A	B	A+B
below	C	D	C+D
	A+C	B+D	$N = n_1 + n_2$

If the hypothesis is true, then we would expect that half of each sample would be above and half below the median. After the table has been created, we can use either the Fisher Test or the X^2 Test in our analysis.

(1) If N is larger than 40, use the X^2 Test corrected for continuity.

(2) If N is between 20 and 40 and no frequency cell is less than 5, use the X^2 Test corrected for continuity.

(3) If N is between 20 and 40 and the smallest frequency cell is less than 5, use the Fisher Test.

(4) If N is less than 20, use the Fisher Test.

In the situation where several data values fall at the median, we change the table categories to that of (greater than) and (less than or equal to).

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 180 of the program. By changing Statement 180, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is *written*. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

M = 86, where M = total combined sample.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of M:

   $(2*M) \leq$ the number of variables available.

2. Select the appropriate value of M for your system from the following table:

CAPACITY	8K	12K
M for System A	86	255

3. Insert System Tape #1 into Unit 1 (on the Console), close the door and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS111AA", and touch RETURN(EXEC).

5. Key LIST 180, and touch RETURN(EXEC).
   The screen should display:

```
180 DIM X(86),S(86):SELECT #110A:
        D=32
```

6. Rekey statement using the new maximum parameters:

```
180 DIM X(M),S(M):SELECT #110A:D=32
```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS111AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Test the following samples for difference in central tendencies.

A	77	63	74	44	81			
B	85	54	68	39	71	64	57	67

$n_1 = 5 \quad n_2 = 8$

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS111AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY. ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Test the following samples for difference in central tendencies.

A	77	63	74	44	81			
B	85	54	68	39	71	64	57	67

$n_1 = 5$ $n_2 = 8$

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F110 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER SIZE OF SAMPLE 1 ?_	9. The size of Sample 1 = 5, touch RETURN(EXEC).
10. INPUT PARAMETERS ENTER SIZE OF SAMPLE 2 ?_	10. The size of Sample 2 = 8, touch RETURN(EXEC).

Example

Test the following samples for difference in central tendencies.

A	77	63	74	44	81			
B	85	54	68	39	71	64	57	67

$n_1 = 5 \quad n_2 = 8$

DISPLAYS	INSTRUCTIONS
11. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9. NOTE: The parameters are displayed for verification.
12. DATA INPUT FOR SAMPLE 1, ITEM #1 ENTER DATA VALUE ?_	12. Sample 1, item 1 = 77, touch RETURN(EXEC).
13. DATA INPUT FOR SAMPLE 1, ITEM #2 ENTER DATA VALUE ?_	13. Sample 1, item 2 = 63, touch RETURN(EXEC).

Enter all items in Sample 1 of example.

DISPLAYS	INSTRUCTIONS
14. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS # 1-5 IS DATA OK (Y OR N) ?_	14. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, enter 'Y' and touch RETURN(EXEC).
15. DATA INPUT FOR SAMPLE 2, ITEM #1 ENTER DATA VALUE ?_	15. Sample 2, item 1 = 85, touch RETURN(EXEC).

Example

Test the following samples for difference in central tendencies.

A	77	63	74	44	81			
B	85	54	68	39	71	64	57	67

$n_1 = 5 \quad n_2 = 8$

DISPLAYS	INSTRUCTIONS
16. DATA INPUT FOR SAMPLE 2, ITEM #2 ENTER DATA VALUE ?_	16. Sample 2, item 2 = 54, touch RETURN(EXEC).

Enter all items in Sample 2 of example.

DISPLAYS	INSTRUCTIONS
17. CORRECTION ROUTINE FOR SAMPLE 2, ITEMS #1-8 IS DATA OK (Y OR N) ?_	17. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, enter 'Y' and touch RETURN(EXEC).
18. REMOVE AND LABEL VOL 1 OF FILE NPS1F110 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	18. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 19.
19. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	19. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 25.
20. ENTER OUTPUT DEVICE TYPE SYMBOL	20. Enter an output device symbol and touch RETURN(EXEC).

Example

Test the following samples for difference in central tendencies.

A	77	63	74	44	81			
B	85	54	68	39	71	64	57	67

$n_1 = 5 \quad n_2 = 8$

DISPLAYS

```
FOR CRT ONLY,        KEY RETURN(EXEC)
FOR HIGH SPEED,      KEY 'HS'
FOR THERMAL,         KEY 'TH'
FOR PLOTTER(2202),   KEY 'P'
FOR TYPEWRITER,      KEY 'TY'
```

INSTRUCTIONS

DISPLAYS

```
21. MOUNT VOL 1 OF FILE
    NPS1F110 - UNIT 1
    KEY RETURN(EXEC) TO RESUME
    ?_
```

INSTRUCTIONS

21. Mount the indicated cassette and touch RETURN(EXEC).

> NOTE:
> If step 7 was answered negatively, ignore this step and go to step 22b.

DISPLAYS

22a. READING DATA RECORD

INSTRUCTIONS

22a. The system now is reading the data record.

DISPLAYS

b. SORTING DATA

INSTRUCTIONS

b. The system now is sorting the data.

DISPLAYS

```
23a. ENTER ALPHA FOR TOCHER'S
     VALUE (- NUMBER IF NONE)
     ?_
```

INSTRUCTIONS

23a. Enter .05 and touch RETURN(EXEC). If a negative number is entered, go to step 24.

> NOTE:
>
> If one of the output printers was selected, the message PRINTING RESULTS is displayed.

DISPLAYS

```
b. IS PARAMETER OK (Y OR N)
   ?_
```

INSTRUCTIONS

b. Enter 'Y' or 'N' and touch RETURN(EXEC).

If 'Y', go to the next step.
If 'N', go to step 23a.

> NOTE:
>
> Steps 23a and 23b only appear when a Fisher's Test is executed.

DISPLAYS

24. EXECUTING PROGRAM

INSTRUCTIONS

24. The system now is executing the Median Test.

Example

Test the following samples for difference in central tendencies.

A	77	63	74	44	81			
B	85	54	68	39	71	64	57	67

$n_1 = 5 \quad n_2 = 8$

DISPLAYS	INSTRUCTIONS
25. STOP END OF PROGRAM :_	25. The test results are displayed for verification.
	26. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

DISPLAYS	INSTRUCTIONS
A. INPUT INFORMATION DO YOU WISH TO CORRECT DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 20.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F110 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F110 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-5 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.

Example

Test the following samples for difference in central tendencies.

A	77	63	74	44	81			
B	85	54	68	39	71	64	57	67

$n_1 = 5 \quad n_2 = 8$

DISPLAYS	INSTRUCTIONS
	NOTE: The input data is displayed for verification in steps C and D.
D. CORRECTION ROUTINE FOR SAMPLE 2, ITEMS #1-8 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 18. If 'N', go to SECTION III.

SECTION III
DATA CORRECTION

A. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-5 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the item in error and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-5 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC). NOTE: Follow steps A and B for all items. If proceeding from either step 14 or step 17, one of those steps reappears; follow the appropriate operating instructions. If proceeding from either step C or step D of Section II, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE MEDIAN TEST
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


SIZE OF SAMPLE 1 =  5
SIZE OF SAMPLE 2 =  8


DATA INPUT FOR SAMPLE 1:

 77              63              74              44              81


DATA INPUT FOR SAMPLE 2:

 85              54              68              39              71
 64              57              67


SORTED DATA (COMBINED SAMPLE):

 39              44              54              57              63
 64              67              68              71              74
 77              81              85
                 MEDIAN =  67


THE MEDIAN TEST
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


SIZE OF SAMPLE 1 =  5
SIZE OF SAMPLE 2 =  8

ALPHA = 0.0500


INTERMEDIATE CONTINGENCY TABLES USED:

A              B              C           D           P(I)
 2              3              5           3           .3263403263404
 1              4              6           2           8.15850815E-02
 0              5              7           1           4.66200466E-03
```

```
THE MEDIAN TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SIZE OF SAMPLE 1 =  5
SIZE OF SAMPLE 2 =  8

ALPHA = 0.0500


GENERATED CONTINGENCY TABLE:

                A =  3          B =  3
                C =  2          D =  5


       P =  .4125874125874
TOCHER P = -.1110714285711

END OF PROGRAM
```

CHAPTER XIV THE MANN-WHITNEY U TEST

PROGRAM ABSTRACT

The program tests to determine if two samples are drawn from the same population or have the same distribution. The data is measured on an ordinal scale.

PROGRAM DESCRIPTION

In the case of two independent samples, we can test to determine if the differences in the samples are convincing proof that there is a difference in the two processes applied to them. The samples may be of unequal size. The data that constitutes the two samples may be either drawn randomly from two populations or arise from random assignment of two treatments to the members of some arbitrary sample. The usual parametric test is to apply a t-test to the means of the two groups. This requires that the data values are independent and drawn from normal populations with equal variances. Also the scores are measured on at least an interval scale. Many times, these assumptions cannot be realistically met. A nonparametric test which can be used is the Mann-Whitney U Test.

The U Test is used to test if two independent samples are from the same population. The data is measured on an ordinal scale. It is one of the most powerful nonparametric tests and is a most useful alternative to the t-test. The null hypothesis is that the two samples have the same distribution. Let n_1 be the sample size of the smaller sample and n_2 be the larger sample size. We combine both groups into one and rank in order of increasing algebraic size. Now focusing upon one group, say n_1 sample, we determine the number of times that a score from n_2 sample precedes a score in n sample and accumulates for the U value. For example, given the following rank values where X is from group n_1 and Y is from group n_2 , we find U: $n_1 = 4$, $n_2 = 6$.

$$\underline{Y}\ \underline{Y}\ X\ \underline{Y}\ X\ \underline{Y}\ X\ X\ \underline{Y}\ \underline{Y}$$

Focusing on n_1, $U = 0 + 0 + 1 + 2 + 4 + 4 = 11$. The number of times that an X score precedes a Y score is U=11. Suppose we happen to focus on the wrong score. Then the U value we have determined is too large for use. Then this too large value is designated as U'. $U = n_1n_2 - U'$. Focusing on n_2 in our example, $U = 2 + 3 + 4 + 4 = 13$. Let us assume that this value is actually U'. Then $U = (4x6) - 13 = 11$ which is what we determined U to be. However, this method of computation of U is tedious for large sample sizes. An alternative method uses the following formula(s):

$$U = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1$$

or

$$U = n_1 n_2 + \frac{n_2 (n_2 + 1)}{2} - R_2$$

where R_1 = sum of the ranks assigned to sample of size n_1.

R_2 = sum of ranks assigned to sample of size n_2.

The formula $U = n_1 n_2 - U'$ still applies here, and the smaller of the two values is used in the analysis. In the case of tied values, the rank assigned to each is the average rank.

To test for significance, we have several choices:

(1) If n_2 is less than or equal to 8, we use a specific table generated for small samples.

(2) If n_2 is between 9 and 20, we use a specific table generated for larger samples.

(3) If n_2 is larger than 20, a normal approximation, N(0,1) is used:

$$\mu_U = \frac{n_1 n_2}{2}, \quad \sigma_U = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}, \quad z = \frac{U - \mu_U}{\sigma_U}$$

If there are tied values in the sample,

$$\sigma_U = \sqrt{\frac{n_1 n_2}{N(N-1)} \left(\frac{N^3 - N}{12} - \Sigma T \right)}$$

where $N = n_1 + n_2$

$$T = \frac{t^3 - t}{12}$$ (where t = number of values tied at a specific rank)

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

M = 69, where M = total combined sample.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of M:

   $(3*M) \leq$ the number of variables available.

2. Select the appropriate value of M for your system from the following table:

CAPACITY	8K	12K	16K
M for System A	69	240	255

3. Insert System Tape #1 into Unit 1 (on the Console), close the door and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS112AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).
   The screen should display:

```
170 DIM X(69),S(69),A(69):SELECT #110A:
    D=32
```

6. Rekey statement using the new maximum parameters:

```
170 DIM X(M),S(M),A(M):SELECT #110A:
    D=32
```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS112AA" and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1 Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Test to see if the two samples are from the same distribution:

A							
12	14	12	8	10	11	9	9
9	15	12	9	10	14	9	12

$n_A = 16$

B							
17	10	8	13	17	15	16	14
17	14	12	15	10	14	16	12
13	19	16	12	14	18	15	

$n_B = 23$

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS112AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)

Example

Test to see if the two samples are from the same distribution:

A	12	14	12	8	10	11	9	9
	9	15	12	9	10	14	9	12

$n_A = 16$

	17	10	8	13	17	15	16	14
B	17	14	12	15	10	14	16	12
	13	19	16	12	14	18	15	

$n_B = 23$

DISPLAYS	INSTRUCTIONS
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?-	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?-	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.

Example

Test to see if the two samples are from the same distribution:

A	12	14	12	8	10	11	9	9
	9	15	12	9	10	14	9	12

$n_A = 16$

	17	10	8	13	17	15	16	14
B	17	14	12	15	10	14	16	12
	13	19	16	12	14	18	15	

$n_B = 23$

DISPLAYS	INSTRUCTIONS
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F120 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER SIZE OF SMALLEST SAMPLE ?_	9. Smallest sample size = 16, touch RETURN(EXEC).
10. INPUT PARAMETERS ENTER SIZE OF LARGEST SAMPLE ?_	10. Largest sample size = 23, touch RETURN(EXEC).
11. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9. NOTE: The parameters are displayed for verification.
12. DATA INPUT FOR SMALLEST SAMPLE, ITEM #1 ENTER DATA VALUE ?_	12. Smallest sample, item #1=12, touch RETURN(EXEC).
13. DATA INPUT FOR SMALLEST SAMPLE, ITEM #2 ENTER DATA VALUE. ?_	13. Smallest sample, item #2=14, touch RETURN(EXEC).

Example

Test to see if the two samples are from the same distribution:

A								
	12	14	12	8	10	11	9	9
	9	15	12	9	10	14	9	12

$n_A = 16$

B								
	17	10	8	13	17	15	16	14
	17	14	12	15	10	14	16	12
	13	19	16	12	14	18	15	

$n_B = 23$

DISPLAYS	INSTRUCTIONS
Enter all items in the smallest sample of the example.	
14. CORRECTION ROUTINE FOR SMALLEST SAMPLE, ITEMS #1-16 IS DATA OK (Y OR N) ?_	14. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, touch RETURN(EXEC).
15. DATA INPUT FOR LARGEST SAMPLE, ITEM #1 ENTER DATA VALUE ?_	15. Largest sample, item #1=17, touch RETURN(EXEC).
16. DATA INPUT FOR LARGEST SAMPLE, ITEM #2 ENTER DATA VALUE ?_	16. Largest sample, item #2=10, touch RETURN(EXEC).
Enter all items in the largest sample of the example.	
17. CORRECTION ROUTINE FOR LARGEST SAMPLE, ITEMS #1-23 IS DATA OK (Y OR N) ?_	17. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.

Example

Test to see if the two samples are from the same distribution:

A	12	14	12	8	10	11	9	9
	9	15	12	9	10	14	9	12

$n_A = 16$

	17	10	8	13	17	15	16	14
B	17	14	12	15	10	14	16	12
	13	19	16	12	14	18	15	

$n_B = 23$

DISPLAYS	INSTRUCTIONS
	NOTE: The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, touch RETURN(EXEC).
18. REMOVE AND LABEL VOL 1 OF FILE NPS1F120 - UNIT 1 KEY RETURN(EXEC) ?_	18. After labeling the cassette, touch RETURN(EXEC). **NOTE:** If step 7 was answered negatively, ignore this step and go to step 19.
19. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	19. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 23.
20. ENTER OUTPUT DEVICE TYPE SYMBOL ?_ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	20. Enter an output device symbol and touch RETURN(EXEC).

Example

Test to see if the two samples are from the same distribution:

A	12	14	12	8	10	11	9	9
	9	15	12	9	10	14	9	12

$n_A = 16$

	17	10	8	13	17	15	16	14
B	17	14	12	15	10	14	16	12
	13	19	16	12	14	18	15	

$n_B = 23$

DISPLAYS	INSTRUCTIONS
21. MOUNT VOL 1 OF FILE NPS1F120 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	21. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 22b.
22a. READING DATA RECORD	22a. The system now is reading the data records.
b. SORTING DATA	b. The system now is sorting the data.
c. SETTING UP AVERAGE RANKS	c. The system is setting up average ranks.
d. EXECUTING PROGRAM	d. The system now is executing the Mann-Whitney U Test.
23. STOP END OF PROGRAM :_	23. The test results are displayed for verification.
	24. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

Example

Test to see if the two samples are from the same distribution:

A	12	14	12	8	10	11	9	9
	9	15	12	9	10	14	9	12

$n_A = 16$

	17	10	8	13	17	15	16	14
B	17	14	12	15	10	14	16	12
	13	19	16	12	14	18	15	

$n_B = 23$

DISPLAYS	INSTRUCTIONS

SECTION I
DATA FROM STORAGE

DISPLAYS	INSTRUCTIONS
A. INPUT INFORMATION DO YOU WISH TO CORRECT DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 20.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F120 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPSF120 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SMALLEST SAMPLE, ITEMS #1-16 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for the smallest sample is displayed for verification.

Example

Test to see if the two samples are from the same distribution:

A	12	14	12	8	10	11	9	9
	9	15	12	9	10	14	9	12

$n_A = 16$

	17	10	8	13	17	15	16	14
B	17	14	12	15	10	14	16	12
	13	19	16	12	14	18	15	

$n_B = 23$

DISPLAYS	INSTRUCTIONS
D. CORRECTION ROUTINE FOR LARGEST SAMPLE, ITEMS #1-23 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 18. If 'N', go to Section III. NOTE: The input data for the largest sample is displayed for verification.

SECTION III
DATA CORRECTION

A. CORRECTION ROUTINE FOR SMALLEST SAMPLE, ITEMS #1-16 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the item number of the data in error and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR SMALLEST SAMPLE, ITEMS #1-16 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC). NOTE: Follow steps A and B for all items. If proceeding from either step 14 or step 17, one of those steps reappears; follow the appropriate operating instructions. If proceeding from either step C or step D of Section II, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE MANN-WHITNEY U TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SMALLEST SAMPLE SIZE =  16
 LARGEST SAMPLE SIZE =  23


DATA INPUT FOR SMALLEST SAMPLE:

 12              14              12              8               10
 11              9               9               9               15
 12              9               10              14              9
 12

DATA INPUT FOR LARGEST SAMPLE:

 17              10              8               13              17
 15              16              14              17              14
 12              15              10              14              16
 12              13              19              16              12
 14              18              15


SORTED DATA (COMBINED SAMPLE):

 8               8               9               9               9
 9               9               10              10              10
 10              11              12              12              12
 12              12              12              12              13
 13              14              14              14              14
 14              14              15              15              15
 15              16              16              16              17
 17              17              18              19


AVERAGE RANK VALUES (- VALUES FROM SMALLEST SAMPLE):

-1.5             1.5            -5              -5              -5
-5              -5              -9.5            -9.5             9.5
 9.5            -12             -16             -16             -16
 16             -16              16              16              20.5
 20.5            24.5            24.5           -24.5            24.5
-24.5            24.5            29.5           -29.5            29.5
 29.5            33              33              33              36
 36              36              38              39
```

```
THE MANN-WHITNEY U TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SMALLEST SAMPLE SIZE =  16
 LARGEST SAMPLE SIZE =  23



SUM OF RANKS FOR SMALLEST SAMPLE =  200
 SUM OF RANKS FOR LARGEST SAMPLE =  580
                 CORRECTION TERM =  70.5

                               U =  64

   MEAN =  184
STD DEV =  34.772986553

   Z =  3.450954660368
P(Z) =  2.79303698E-04


END OF PROGRAM
```

CHAPTER XV THE KOLMOGOROV-SMIRNOV TWO-SAMPLE TEST

PROGRAM ABSTRACT

The program tests to determine whether two samples are in agreement and are drawn from the same population or populations with the same distribution. The one-tail test determines if the values from one sample population are stochastically larger than the other. The two-tail is sensitive to *distribution* differences.

PROGRAM DESCRIPTION

In the case of two independent samples, we can test to determine if the differences in the samples are convincing proof that there is a difference in the two processes applied to them. The samples may be of unequal size. The data that constitutes the two samples may be either drawn randomly from two populations or arise from random assignment of two treatments to the member of some arbitrary sample. The usual parametric test is to apply a t-test to the means of the two groups. This requires that the data values are independent and drawn from normal populations with equal variances. Also the scores are measured on at least an interval scale. Many times, these assumptions cannot be realistically met. A nonparametric test which can be used is the Kolmogorov-Smirnov Two-Sample Test.

The Kolmogorov-Smirnov Test is interested in testing to see whether the two samples are in agreement with each other and whether their respective cumulative distributions are in agreement. Again, the null hypothesis is whether the two samples are drawn from the same population or populations with the same distribution. The two-tailed test is extremely sensitive to differences of any kind between the two sample distributions. The one-tailed test determines whether the values drawn from one population are stochastically larger than those drawn from the other.

To apply the test, we determine the cumulative frequency distribution for each sample, using the same intervals for both. Then at each interval, we determine the difference between the two frequencies, focusing on the largest difference value. Let $Sn_1(X)$ be the observed cumulative step function of one sample, $S=k/n_1$, where k = the number of scores equal to or less than X. And let Sn_2 (X) be the equivalent values for the other sample. Then the test for one-tail is:

$$D = \max \left[S_{n_1}(X) - S_{n_2}(X) \right]$$

and for two-tails:

$$D = \max \left[|S_{n_1}(X) - S_{n_2}(X)| \right]$$

To determine the significance values, we have several choices:

(1) If n_1 or n_2 is less than or equal to 40 and $n_1 = n_2 = N$, then for both one-tail and two-tail tests, we use a table for $K_D = D/N$.

(2) If n_1 or n_2 is less than or equal to 40 and $n_1 \neq n_2$, then for the one-tail test, we use:

$$\chi^2 = 4D^2 \frac{n_1 n_2}{n_1 + n_2} \quad \text{d.f.} = 2$$

though the test is conservative.

(3) For a two-tail test with n_1 and n_2 both larger than 40, we use D and a table for the critical values.

(4) For a one-tail test with n_1 and n_2 both larger than 40, we use

$$\chi^2 = 4D^2 \frac{n_1 n_2}{n_1 + n_2} \quad \text{d.f.} = 2$$

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 180 of the program. By changing Statement 180, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

Y = 27 where Y = max (sample size 1, size 2).
E = 27 where E = # of intervals.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the values of Y and E:

   $2 * (Y+E) \leq$ the number of variables available.

2. Calculate the maximum Y,E, using the above formula and the following table:

CAPACITY	8K	12K	16K
# of variables available for System A	108	620	1132

3. Insert System Tape #1 into Unit 1 (on the Console), close the door and press REWIND. Key CLEAR, and touch RETURN(EXEC).

4. Key LOAD "NPS113AA", and touch RETURN(EXEC).

5. Key LIST 180, and touch RETURN(EXEC).
   The screen should display:

```
180 DIM X(2,27),F(2,27):SELECT #110A:
    D=32
```

6. Rekey statement using the new maximum parameters:

```
180 DIM X(2,Y),F(2,E):SELECT #110A:
    D=32
```

7. Touch RETURN(EXEC).

8. Remove System Tape #1 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS113AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #1. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals. Only test for 1 tail.

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 1 program, follow operating instructions A. To bypass the MENU 1 program, follow operating instructions B. A. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter I. B. Mount the Nonparametric System Tape #1 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS113AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals. Only test for 1 tail.

DISPLAYS	INSTRUCTIONS
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/YY/DD ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT INFORMATION FROM KEYBOARD 'K' OR STORAGE 'S' ?-	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?-	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F130 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals. Only test for 1 tail.

DISPLAYS	INSTRUCTIONS
9. INPUT SAMPLE SIZES ENTER SIZE OF SAMPLE 1 ?_	9. Sample 1 = 10, touch RETURN (EXEC).
10. INPUT SAMPLE SIZES ENTER SIZE OF SAMPLE 2 ?_	10. Sample 2 = 12, touch RETURN (EXEC).
11. INPUT SAMPLE SIZES IS SAMPLE SIZE INPUT OK (Y OR N) ?_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9. NOTE: The sample sizes are displayed for verification.
12. INPUT INFORMATION IS FREQUENCY TABLE KNOWN (Y OR N) ?_	12. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', skip steps 16 and 17.
13. INPUT PARAMETERS ENTER # OF INTERVALS ?_	13. The number of intervals = 8, touch RETURN(EXEC).
14. INPUT PARAMETERS ENTER # OF TAILS IN TEST ?_	14. The number of tails = 1, touch RETURN(EXEC). NOTE: Step 15 only appears when a 2-tail test is executed, where n_1 and n_2 are larger than 40.

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals. Only test for 1 tail.

DISPLAYS	INSTRUCTIONS
15. INPUT PARAMETERS ENTER CRITICAL VALUE CONSTANT ?_	15. Critical value constant = .05, touch RETURN(EXEC).
16. INPUT PARAMETERS ENTER SIZE OF INTERVALS ?_	16. Size of intervals = 4, touch RETURN(EXEC).
17. INPUT PARAMETERS ENTER STARTING VALUE OF 1ST INTERVAL ?_	17. Starting value of the first interval = 21.
18. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?-	18. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 13.
19. DATA INPUT FOR SAMPLE 1, ITEM #1 ENTER DATA VALUE ?_	19. Sample 1, item 1 = 37.1, touch RETURN(EXEC).
20. DATA INPUT FOR SAMPLE 1, ITEM #2 ENTER DATA VALUE ?_	20. Sample 1, item 2 = 39.2, touch RETURN(EXEC).

Enter all items in Sample 1 of example.

DISPLAYS	INSTRUCTIONS
21. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS # 1-10 IS DATA OK (Y OR N) ?-	21. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals. Only test for 1 tail.

DISPLAYS	INSTRUCTIONS
	NOTE: The input data for Sample 1 is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, enter 'Y' and touch RETURN(EXEC).
22. DATA INPUT FOR SAMPLE 2, ITEM #1 ENTER DATA VALUE ?_	22. Sample 2, item 1 = 33.2, touch RETURN(EXEC).
23. DATA INPUT FOR SAMPLE 2, ITEM #2 ENTER DATA VALUE ?_	23. Sample 2, item 2 = 37.2, touch RETURN(EXEC).

Enter all items in Sample 2 of example.

DISPLAYS	INSTRUCTIONS
24. CORRECTION ROUTINE FOR SAMPLE 2, ITEMS #1-12 IS DATA OK (Y OR N) ?_	24. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample 2 is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, enter 'Y' and touch RETURN(EXEC).

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals.
Only test for 1 tail.

DISPLAYS

25. REMOVE AND LABEL VOL 1 OF
    FILE NPS1F130 - UNIT 1
    KEY RETURN(EXEC) TO RESUME
    ?_

26. DO YOU WISH TO EXECUTE
    PROGRAM (Y OR N)
    ?_

27. ENTER OUTPUT DEVICE TYPE
    SYMBOL
    ?_

FOR CRT ONLY, KEY RETURN(EXEC)
FOR HIGH SPEED, KEY 'HS'
FOR THERMAL, KEY 'TH'
FOR PLOTTER(2202), KEY 'P'
FOR TYPEWRITER, KEY 'TY'

28. MOUNT VOL 1 OF FILE NPS1F130
    - UNIT 1
    KEY RETURN(EXEC) TO RESUME
    ?_

29a. READING DATA RECORD

b. BUILDING FREQUENCY FILES

INSTRUCTIONS

25. After labeling the cassette, touch RETURN(EXEC).

NOTE:

If step 7 was answered negatively, ignore this step and go to the step 26.

26. Enter 'Y' or 'N' and touch RETURN(EXEC).

If 'Y', go to the next step.
If 'N', go to step 31.

27. Enter an output device symbol and touch RETURN(EXEC).

28. Mount the indicated cassette and touch RETURN(EXEC).

NOTE:

If step 7 was answered negatively, ignore this step and go to step 29b.

29a. The system now is reading data records.

b. The system now is building frequency files.

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals. Only test for 1 tail.

DISPLAYS	INSTRUCTIONS
c. EXECUTING PROGRAM	c. The system now is executing the Kolmogorov-Smirnov Two-Sample Test.
30. ANALYSIS INFORMATION REVERSE FREQUENCY TABLE VALUES (Y OR N) ?_	30. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', the system displays: a. REVERSING FREQUENCY TABLE b. EXECUTING PROGRAM. If 'N', go to the next step. NOTE: The test results are displayed for verification.
31. STOP END OF PROGRAM :_	31. The test results are displayed for verification.
	32. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 27.

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals. Only test for 1 tail.

DISPLAYS	INSTRUCTIONS

SECTION II
ONE TAPE DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F130 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F130 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-10 IS DATA OK (Y OR N) ?-	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample 1 is displayed for verification. If more than 32 items are entered, only the first 32 items are displayed; to view the remaining items, enter 'Y' and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR SAMPLE 2, ITEMS #1-12 IS DATA OK (Y OR N) ?-	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 25. If 'N', go to Section III.

Example

Test the following two samples for agreement:

A	37.1	39.2	43.2	44.2	46.4	46.7	53	38.6
	50.1	45.2						

B	33.2	37.2	38.9	36.1	32.4	27.1	39.8	22.3
	30.4	30.6	41.3	40				

Interval starts at 21, at increments of 4. There are 8 intervals. Only test for 1 tail.

DISPLAYS	INSTRUCTIONS
	NOTE: The input data for Sample 2 is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, enter 'y' and touch RETURN(EXEC).

SECTION III
DATA CORRECTION

A. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-10 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the item number of the data in error and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-10 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC). NOTE: Follow steps A and B for Sample 2. If proceeding from either step 21 or step 24, one of those steps reappears; follow the appropriate operating instructions. If proceeding from either step C or step D of Section II, one of those steps reappears; follow the appropriate operating instructions.

```
THE KOLMOGOROV-SMIRNOV TWO-SAMPLE TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

SIZE OF SAMPLE 1 =  10
SIZE OF SAMPLE 2 =  12

    # OF INTERVALS =  8
# OF TAILS IN TEST =  1

 SIZE OF INTERVALS =  4
1ST INTERVAL VALUE =  21

DATA INPUT FOR SAMPLE 1

 37.1         39.2         43.2         44.2         46.4
 46.7         53           38.6         50.1         45.2

DATA INPUT FOR SAMPLE 2

 33.2         37.2         38.9         36.1         32.4
 27.1         39.8         22.3         30.4         30.6
 41.3         40


THE KOLMOGOROV-SMIRNOV TWO-SAMPLE TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

SIZE OF SAMPLE 1 =  10
SIZE OF SAMPLE 2 =  12

    # OF INTERVALS =  8
# OF TAILS IN TEST =  1

 SIZE OF INTERVALS =  4
1ST INTERVAL VALUE =  21

FREQUENCY TABLE:

  I   F1   F2  CF1  CF2        S1        S2        D1        D2

  1    0    1    0    1  0.000000  0.083333 -0.083333  0.083333
  2    0    1    0    2  0.000000  0.166666 -0.166666  0.166666
  3    0    3    0    5  0.000000  0.416666 -0.416666  0.416666
  4    0    2    0    7  0.000000  0.583333 -0.583333  0.583333
  5    3    4    3   11  0.300000  0.916666 -0.616666  0.616666
  6    2    1    5   12  0.500000  1.000000 -0.500000  0.500000
  7    3    0    8   12  0.800000  1.000000 -0.200000  0.200000
  8    2    0   10   12  1.000000  1.000000  0.000000  0.000000
```

```
THE KOLMOGOROV-SMIRNOV TWO-SAMPLE TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SIZE OF SAMPLE 1 =  10
SIZE OF SAMPLE 2 =  12


    # OF INTERVALS =  8
# OF TAILS IN TEST =  1

 SIZE OF INTERVALS =  4
1ST INTERVAL VALUE =  21


     MAX D =  0
CHI-SQUARE =  0
      D.F. =  2

END OF PROGRAM
```

PROGRAM ABSTRACT

This program contains a routine for accessing anyone of the last 12 programs and a routine for initializing scratch cassettes.

PROGRAM DESCRIPTION

The MENU program for Part II is designed to display the last 12 programs of the Nonparametric Statistics package. After loading and starting the program, the last 12 programs are displayed. These programs are numbered 14-25; the numbers represent the Special Function key used to access the desired program. After depressing the appropriate Special Function key, a prompt appears which asks whether or not the user wishes to initialize scratch cassettes. After initializing the necessary number of cassettes, or if the prompt was answered negatively, the selected program is loaded. Initializing a scratch cassette places a software header record at the beginning of the tape which permits the scratch cassette to be used as a data cassette. Data cassettes can be reused as scratch cassettes without reinitialization.

Each program provides the option of bypassing the MENU program. In bypassing the MENU program, the option to initialize data cassettes is not available.

DISPLAYS	INSTRUCTIONS
	1. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN (EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).

2. KEY S.F. KEY TO ACCESS PROGRAM
?_

S.F.	DESCRIPTION
14	THE WALD-WOLFOWITZ RUNS TEST
15	THE COCHRAN Q TEST
16	THE FRIEDMAN TWO-WAY ANOVA BY RANKS TEST
17	THE CHI-SQUARE TEST FOR K INDEPENDENT SAMPLES
18	THE EXTENSION OF THE MEDIAN TEST (MEDIAN KNOWN)
19	THE EXTENSION OF THE MEDIAN TEST (MEDIAN UNKNOWN)
20	THE KRUSKAL-WALLIS ONE-WAY ANOVA BY RANKS TEST
21	THE CONTINGENCY COEFFICIENT TEST
22	THE SPEARMAN RANK CORRELATION COEFFICIENT TEST
23	THE KENDALL RANK CORRELATION COEFFICIENT TEST
24	THE KENDALL PARTIAL RANK CORRELATION COEFFICIENT TEST
25	THE KENDALL COEFFICIENT OF CONCORDANCE TEST

DISPLAYS	INSTRUCTIONS
	2. Key a Special Function (S.F.) key to access the desired program.
3. DO YOU DESIRE TO INITIALIZE SCRATCH TAPES (Y OR N) ?_	3. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', the system loads the selected program. NOTE: The message RE-ENTER appears if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC).
4. REMOVE PROGRAM CASSETTE FROM LOGICAL UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	4. After removing the program cassette, touch RETURN(EXEC).

DISPLAYS	INSTRUCTIONS
5. MOUNT SCRATCH CASSETTE TO BE LABELED IN LOGICAL UNIT 1 (E=END) KEY RETURN(EXEC) TO RESUME ?_	5. After mounting a scratch cassette, touch RETURN(EXEC). If no more scratch cassettes are to be initialized, type E, touch RETURN(EXEC) and go to the next step.
6. MOUNT PROGRAM CASSETTE IN LOGICAL UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	6. After mounting the program cassette, touch RETURN(EXEC). NOTE: At this time, the selected program is loaded with an appropriate message, for example: LOADING THE WALD-WOLFOWITZ RUNS TEST

CHAPTER XVII THE WALD-WOLFOWITZ RUNS TEST

PROGRAM ABSTRACT

The program is used to test if the two independent samples are drawn from the same population. The variable under consideration is assumed to be continuous and the data measured from at least an ordinal scale. Unlike the other tests, this test is addressed to any difference between the two rather than a specific difference.

PROGRAM DESCRIPTION

In the case of two independent samples, we can test to determine if the differences in the samples are convincing proof that there is a difference in the two processes applied to them. The samples may be of unequal size. The data that constitutes the two samples may be either drawn randomly from two populations or arise from random assignment of two treatments to the members of some arbitrary sample. The usual parametric test is to apply a t-test to the means of the two groups. This requires that the data values are independent and drawn from normal populations with equal variances. Also the scores are measured on at least an interval scale. Many times, these assumptions cannot be realistically met. A nonparametric test which can be used is the Wald-Wolfowitz Runs Test.

The Wald-Wolfowitz Test is useful in testing the null hypothesis that the two independent samples have been drawn from the same population. The alternative hypothesis is that the two groups differ in any respect whatsoever. Thus, there are a large class of alternatives to test. Although the other tests are aimed at a specific sort of difference, this test is addressed to any difference. It assumes that the variable under consideration is continuous, and measurement is at least on an ordinal scale.

To run the test, we first rank the combined sample in increasing order. Then we determine the number of runs. A run is any sequence of values from the same sample. For example, given the following data series:

$$\underline{X\ X\ X}\ \underline{Y}\ \underline{X}\ \underline{Y\ Y}\ \underline{X\ X\ X}\ \underline{Y}\ \underline{X}\ \underline{Y\ Y}$$

From this ordered series, we can determine the number of runs, $r = 8$ for an X group of 8 elements and a Y group of 6 elements. Thus, if the two samples are drawn from the same population, the scores of X's and Y's will be well mixed and r would be large. In the case of tie values, we have a problem. If the values are from the same sample, there is no problem. If they are from both samples, which way do we order them. It is conceivable that the manner in which the tie values are placed will vary the number of runs substantially. The program is written to allow for the rearrangement of two values at a time and the subsequent calculation of r and then critical values.

For significant values, we have two cases:

(1) If n_1 and n_2 are both 20 or smaller, we use the table provided for the test.

(2) If n_1 or n_2 is larger than 20, we use a normal approximation.

$$\mu_r = \frac{2n_1 n_2}{n_1+n_2} + 1 \qquad \sigma_r = \sqrt{\frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1+n_2)^2 (n_1+n_2-1)}}$$

$$z = \frac{|r - \mu_r| - .5}{\sigma_r}$$

This is incorporating a correction for a continuity term when n_1+n_2 is not very large.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

M = 67, where M = total combined sample.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of M:

   3*M $\leq$ the number of variables available.

2. Select the appropriate value of M for your system from the following table:

CAPACITY	8K	12K	16K
M for System A	67	238	255

3. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR and touch RETURN(EXEC).

4. Key LOAD "NPS114AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).
   The screen should display:

```
170 DIM X(67),S(67),A(67):SELECT #110A:
      D=32
```

6. Rekey statement, using the new maximum parameters:

```
170 DIM X(M),S(M),A(M):SELECT #110A:
      D=32
```

7. Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS114AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Test the two samples to see if they were drawn from the same population. $n_1 = 8$, $n_2 = 21$.

A	19	54	28	23	74	55	30	44

B	22	7	23	14	7	5	14	14
	20	22	15	14	23	14	20	14
	17	13	21	14	13			

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN (EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS114AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Test the two samples to see if they were drawn from the same population. $n_1 = 8$, $n_2 = 21$.

A	19	54	28	23	74	55	30	44

B	22	7	23	14	7	5	14	14
	20	22	15	14	23	14	20	14
	17	13	21	14	13			

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F140 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER SIZE OF SAMPLE 1 ?_	9. Sample 1 = 8, touch RETURN(EXEC).

Example

Test the two samples to see if they were drawn from the same population. $n_1 = 8$, $n_2 = 21$.

A	19	54	28	23	74	55	30	44

	22	7	23	14	7	5	14	14
B	20	22	15	14	23	14	20	14
	17	13	21	14	13			

DISPLAYS	INSTRUCTIONS
10. INPUT PARAMETERS ENTER SIZE OF SAMPLE 2 ?_	10. Sample 2 = 21, touch RETURN (EXEC).
11. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?-_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
12. DATA INPUT FOR SAMPLE 1, ITEM #1 ENTER DATA VALUE ?_	12. Sample 1, item 1 = 19, touch RETURN(EXEC).
13. DATA INPUT FOR SAMPLE 1, ITEM #2 ENTER DATA VALUE ?_	13. Sample 1, item 2 = 54, touch RETURN(EXEC).

Enter all items in Sample 1 of example.

DISPLAYS	INSTRUCTIONS
14. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-8 IS DATA OK (Y OR N) ?-_	14. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample 1 is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
15. DATA INPUT FOR SAMPLE 2, ITEM #1 ENTER DATA VALUE ?_	15. Sample 2, item 1 = 22, touch RETURN(EXEC).

Example

Test the two samples to see if they were drawn from the same population. $n_1 = 8$, $n_2 = 21$.

A	19	54	28	23	74	55	30	44

B	22	7	23	14	7	5	14	14
	20	22	15	14	23	14	20	14
	17	13	21	14	13			

DISPLAYS	INSTRUCTIONS
16. DATA INPUT FOR SAMPLE 2, ITEM #2 ENTER DATA VALUE ?_	16. Sample 2, item 2 = 7, touch RETURN(EXEC).

Enter all items in Sample 2 of example.

DISPLAYS	INSTRUCTIONS
17. CORRECTION ROUTINE FOR SAMPLE 2, ITEMS #1-21 IS DATA OK (Y OR N) ?_	17. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample 2 is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, enter 'Y' and touch RETURN(EXEC).
18. REMOVE AND LABEL VOL 1 OF FILE NPS1F140 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	18. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 19.
19. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	19. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 27.
20. ENTER OUTPUT DEVICE TYPE SYMBOL ?_	20. Enter an output device symbol and touch RETURN(EXEC).

Example

Test the two samples to see if they were drawn from the same population. $n_1 = 8$, $n_2 = 21$.

A	19	54	28	23	74	55	30	44

B	22	7	23	14	7	5	14	14
	20	22	15	14	23	14	20	14
	17	13	21	14	13			

DISPLAYS	INSTRUCTIONS
FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER (2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	
21. MOUNT VOL 1 OF FILE NPS1F140 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	21. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 22b.
22a. READING DATA RECORD	22a. The system now is reading the data record.
b. SORTING DATA	b. The system now is sorting the data. NOTE: If anyone of the output printers was selected, the message PRINTING RANKS is displayed.
c. EXECUTING PROGRAM	c. The system now is executing The Wald-Wolfowitz Runs Test.
23. ANALYSIS INFORMATION REARRANGE ID ORDER (Y OR N) ?_	23. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 27.

Example

Test the two samples to see if they were drawn from the same population. $n_1 = 8$, $n_2 = 21$.

A	19	54	28	23	74	55	30	44

B	22	7	23	14	7	5	14	14
	20	22	15	14	23	14	20	14
	17	13	21	14	13			

DISPLAYS	INSTRUCTIONS
	NOTE: The number of runs, Z and P(Z) values, are displayed for verification.
24. SWAP INFORMATION ENTER 1ST SWAP RANK VALUE ?_	24. Enter the first swap rank value and touch RETURN(EXEC).
25. SWAP INFORMATION ENTER 2ND SWAP RANK VALUE ?_	25. Enter the second swap rank value and touch RETURN(EXEC).
26. SWAP INFORMATION SWAP INPUT OK (Y OR N) ?_	26. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', the system executes the test and displays step 23 with the new results. If 'N', go to step 24.
27. STOP END OF PROGRAM :_	27. The test results are displayed for verification.
	28. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I

DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 20.

Example

Test the two samples to see if they were drawn from the same population. $n_1 = 8$, $n_2 = 21$.

A	19	54	28	23	74	55	30	44

B	22	7	23	14	7	5	14	14
	20	22	15	14	23	14	20	14
	17	13	21	14	13			

DISPLAYS	INSTRUCTIONS

SECTION II

ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F140 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F140 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-8 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample 1 and Sample 2 is displayed for verification. If more than 32 items are entered, only the first 32 are displayed; to view the remaining items, enter 'Y' and touch RETURN (EXEC).
D. CORRECTION ROUTINE FOR SAMPLE 2, ITEMS #1-21 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 18. If 'N', go to Section III.

Example

Test the two samples to see if they were drawn from the same population. $n_1 = 8$, $n_2 = 21$.

A	19	54	28	23	74	55	30	44

B	22	7	23	14	7	5	14	14
	20	22	15	14	23	14	20	14
	17	13	21	14	13			

DISPLAYS	INSTRUCTIONS

SECTION III
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-8 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the item in error and touch RETURN(EXEC).
B. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-8 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC).

NOTE:

Follow steps A and B for Sample 2. If proceeding from either step 14 or step 17, one of those steps reappears; follow the appropriate operating instructions. If proceeding from either step C or step D of Section II, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE WALD-WOLFOWITZ RUNS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

SIZE OF SAMPLE 1 =  8
SIZE OF SAMPLE 2 =  21

DATA INPUT FOR SAMPLE 1:

 19            54            28            23            74
 55            30            44

DATA INPUT FOR SAMPLE 2:

 22            7             23            14            7
 5             14            14            20            22
 15            14            23            14            20
 14            17            13            21            14
 13


SORTED DATA (COMBINED SAMPLE):

 5             7             7             13            13
 14            14            14            14            14
 14            14            15            17            19
 20            20            21            22            22
 23            23            23            28            30
 44            54            55            74


RANK VALUES (- VALUES FROM SAMPLE 1)

 1             2             3             4             5
 6             7             8             9             10
 11            12            13            14           -15
 16            17            18            19            20
 21            22           -23           -24           -25
-26           -27           -28           -29


THE WALD-WOLFOWITZ RUNS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

SIZE OF SAMPLE 1 =  8
SIZE OF SAMPLE 2 =  21

# OF RUNS =  4

   Z =  3.863518857093
P(Z) =  5.58826422E-05


END OF PROGRAM
```

CHAPTER XVIII THE COCHRAN Q TEST

PROGRAM ABSTRACT

The program tests to see whether three or more (k) matched sets of frequencies or proportions differ significantly among themselves. It is particularly useful for nominal or dichotomized ordinal data.

PROGRAM DESCRIPTION

Let us look at the procedures for testing for the significance of differences among three or more groups. The null hypothesis states that k (3 or more) samples have been drawn from the same population or identical populations. Such a test is used when comparing three or more samples or conditions to determine whether there is an over-all difference among the k samples or conditions before any pair of samples is picked out in order to determine the significance of the difference between them. Only after we have rejected the null hypothesis by some k-sample test are we justified in testing any two of the k samples for significant differences. The parametric test used in testing to see if several samples are drawn from identical populations is the analysis of variance or F-test. However, we must assume that the data is drawn independently from normally distributed populations, the populations have the same variance, the means in the populations are linear combinations of effects due to rows and columns, and the variables are at least measured from an interval scale. Many times these assumptions cannot be realistically met. A nonparametric test for the case of k related samples is the Cochran Q Test.

The Cochran Q Test is just an extension of the McNemar Test for two related samples. It is a method to test whether three or more (k) matched sets of frequencies or proportions differ significantly among themselves. The test is particularly suitable for data measured in a nominal scale or for dichotomized ordinal data. It is conceivable that a wide variety of research hypotheses may be analyzed by the Cochran Test. The data could consist of pass-fail answers on k items for N individuals. Or it could compare the responses of N subjects under k different conditions to one item under analysis. Or it could compare responses to one item for N sets having k matched persons per set.

Let us arrange the data in a two-way table with N rows and k columns. The null hypothesis states that the proportion or frequency of responses of a particular kind is the same in each column, except for chance differences. If the null hypothesis is true and the number of rows is not too small, the Q is distributed approximately Chi-Square with (k-1) degrees of freedom. The Q-value is computed from the following formula:

$$Q = \frac{k(k-1)\sum_{j=1}^{k}(G_j - \overline{G})^2}{k\sum_{i=1}^{N}L_i - \sum_{i=1}^{N}L_i^2}$$

$$= \frac{(k-1)\left[k \sum_{j=1}^{k} G_j^2 - \left(\sum_{j=1}^{k} G_j\right)^2\right]}{k \sum_{i=1}^{N} L_i - \sum_{i=1}^{N} L_i^2}$$

where G_j = Total number of successes in column j.

$\overline{G}$ = mean of G.

L_i = Total number of successes in row i.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

After information is temporarily stored internally in the System 2200, it is stored permanently on a tape cassette. When the system is turned off, information stored in the system is lost, but information stored on the tape cassette remains intact.

The observations on the tape are arranged in groups called records. In this program, one row is a record. During entry, the record is written on the tape after the entire cell is entered and checked.

Because the tape has a fixed length, a maximum number of records can be written on it. Two lengths are available: 75 feet (Wang Part # 174-1250) and 150 feet (Wang Part # 174-1251). The program is designed for use of 150 foot tapes.

The length of a record depends on the number of columns. The maximum number of records on the tape cassette depends on the length of the record. If all the data cannot be stored on a single cassette, two or more cassettes are used. As the records are written, they are counted. When the maximum is reached, cassette changing messages are displayed (only one data cassette is allowed in the System S).

As it is sold, the program contains the following maximum parameters:

System A: C = 93, 72 for the maximum number of records per cassette.

System S: C = 160, 47 for the maximum number of records per cassette.

Where C = # of columns.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of C:

   $(2*C) \leq$ the number of variables available.

2. Select the appropriate value of C for your system from the following table:

CAPACITY	8K	12K
C for System A	93	255
C for System S	160	255

3. Look up the maximum number of records per cassette (D') in the following table:

Maximum C

	24	52	80	108	136	164	172	220	248	255
75 feet	146	72	47	35	27	22	19	16	14	12
150 feet	296	147	97	72	57	47	40	35	34	27

*If your max C is not listed, refer to the next highest increment.

NOTE:

In the System S, the number of records used is not checked against the number allowed. Remember not to exceed the table value or an error results.

4. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR and touch RETURN(EXEC).

5. Key LOAD "NPS115AA" for the System A or LOAD "NSS115AA" for the System S, and touch RETURN(EXEC).

6. Key LIST 170, touch RETURN(EXEC). The screen should display:

   System A: 170 DIM X(93),G(93):SELECT #110A,#210B:
   D=72:H=32

   System S: 170 DIM X(160),G(160):SELECT #110A:H=32

7. Rekey Statement 170, using the new maximum parameters:

   System A: 170 DIM X(C),G(C):SELECT #110A,#210B:D=D':
   H=32

   System S: 170 DIM X(C),G(C):SELECT #110A:H=32

   Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS115AA" for the System A, or "NSS115AA" for the System S, and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS115AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). (For the System S, the program name is "NSS115AA".)
2. TEST INFORMATION ENTER PROJECT NAME ?----------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?----------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)

Example

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS	INSTRUCTIONS
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F150 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	7. Mount a scratch cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F150.)
8. INPUT PARAMETERS ENTER # OF ROWS ?_	8. The number of rows = 5, touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER # OF COLUMNS ?_	9. The number of columns = 10, touch RETURN(EXEC).

__Example__

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS	INSTRUCTIONS
10. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 8. NOTE: The parameters are displayed for verification.
11. DATA INPUT FOR ROW #1, COLUMN 1 ENTER DATA VALUE (0/1) ?_	11. Row 1, column 1 = 0, touch RETURN(EXEC).
12. DATA INPUT FOR ROW #1, COLUMN 2 ENTER DATA VALUE (0/1) ?_	12. Row 1, column 2 = 1, touch RETURN(EXEC).

Enter all items in Row 1 of example.

DISPLAYS	INSTRUCTIONS
13. CORRECTION ROUTINE FOR ROW # 1, ITEMS #1-10 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section IV. NOTE: The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

Example

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS	INSTRUCTIONS
	Follow steps 11-13 to enter all rows. For the System A only: the System A program is written to handle multi-volume files of data. The program contains a constant value that dictates the number of records which can be stored per tape cassette. Once this number of records has been written, the volume is closed and the following example instructions are displayed, after data cassette 1 has been rewound. a. REMOVE AND LABEL VOL 1 OF FILE NPS1F150 - UNIT 1 KEY RETURN(EXEC) TO RESUME. ?_ b. MOUNT SCRATCH VOL TO BECOME VOL 2 OF FILE NPS1F150 - UNIT 1 KEY RETURN(EXEC) TO RESUME. ?_
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F150 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC). (For the System S, the file name is NSS1F150.)
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?_	16. Enter an output device symbol and touch RETURN(EXEC).

Example

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS	INSTRUCTIONS
FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	
17. MOUNT VOL 1 OF FILE NPS1F150 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F150.) NOTE: If Volume 1 already is in Unit 1 from the corrections routine, ignore this step which is repeated for all volumes in a multi-volume System A.
18. EXECUTING PROGRAM	18. The system now is executing the Cochran Q Test.
19. STOP END OF PROGRAM :_	19. The test results are displayed for verification.
	20. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 16.

Example

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS	INSTRUCTIONS
B. MOUNT VOL 1 OF FILE NPS1F150 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F150. Go to Section II.)
C. ENTER # OF TAPE DRIVES (1 OR 2) ?_	C. Enter 1 or 2 and touch RETURN (EXEC). If 1, go to Section II. If 2, go to Section III.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. ROW # IN ERROR (0 IF END) ?_	A. Enter the row in error or 0 and touch RETURN(EXEC). If a row number is entered, go to the next step. If '0', go to step 15. NOTE: If the data file contains more than one volume, the program determines the location of the record and displays the appropriate volume to mount. See step B. For the System S, ignore step B.
B. MOUNT VOL 2 OF FILE NPS1F150 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated volume and touch RETURN(EXEC).

Example

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS

C. CORRECTION ROUTINE FOR
ROW #1, ITEMS #1-10
IS DATA OK (Y OR N)
?_

INSTRUCTIONS

C. Enter 'Y' or 'N' and touch RETURN(EXEC).

If 'Y', go to step A of Section II.
If 'N', go to Section IV.

NOTE:

Follow steps A-C for all corrections. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION III
TWO TAPE DRIVE CORRECTION

A. ROW # IN ERROR (0 IF END)
?_

A. Enter the row in error or 0 and touch RETURN(EXEC).

If a row number is entered, go to the next step.
If '0', go to step 15.

NOTE:

Row numbers must be entered sequentially.

B. MOUNT VOL 2 OF FILE NPS1F150
- UNIT 1
KEY RETURN(EXEC) TO RESUME
?_

B. Mount the indicated cassette and touch RETURN(EXEC).

NOTE:

This prompt only appears when the row selected is not located in Volume 1.

Example

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS	INSTRUCTIONS
C. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F150 - UNIT 2 KEY RETURN(EXEC) TO RESUME ?_	C. Mount a scratch cassette in Unit 2 and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-10 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section III. If 'N', go to Section IV. NOTE: The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN (EXEC).

SECTION IV
DATA CORRECTION

A. CORRECTION ROUTINE FOR ROW #1 ITEMS #1-10 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the item in error and touch RETURN(EXEC). NOTE: If the row selected contains only one item, ignore this step.

Example

Run a Cochran Q test on the following data: k = 10, N = 5.

	1	2	3	4	5	6	7	8	9	10
1	0	1	1	0	1	0	1	0	1	0
2	0	1	1	1	1	1	1	1	1	0
3	1	1	0	1	0	0	0	1	0	1
4	1	0	1	0	1	0	0	0	0	0
5	1	0	0	1	0	1	1	0	0	1

DISPLAYS

B. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-10
ENTER CORRECT DATA VALUE
?_

INSTRUCTIONS

B. Enter the correct data value and touch RETURN(EXEC).

NOTE:

Follow steps A-B for all samples. If proceeding from step 13, that step reappears; follow the appropriate operating instructions. If proceeding from either step C of Section II or Step D of Section III, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE COCHRAN Q TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

   # OF ROWS =  5
# OF COLUMNS =  10

INPUT DATA:

ROW # 1
 0          1          1          0          1
 0          1          0          1          0

ROW # 2
 0          1          1          1          1
 1          1          1          1          0

ROW # 3
 1          1          0          1          0
 0          0          1          0          1

ROW # 4
 1          0          1          0          1
 0          0          0          0          0

ROW # 5
 1          0          0          1          0
 1          1          0          0          1
```

```
THE COCHRAN Q TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


   # OF ROWS =  5
# OF COLUMNS =  10


COLUMN TOTALS G(I):

 3              3              3              3              3
 2              3              2              2              2


  SUM(L) =  26
SUM(L^2) =  148


   Q =  1.928571428571
D.F. =  9


END OF PROGRAM
```

CHAPTER XIX THE FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE BY RANKS TEST

PROGRAM ABSTRACT

The program is used to test k samples to determine if they were drawn from the same population. The data is from an ordinal scale.

PROGRAM DESCRIPTION

Let us look at the procedures for testing for the significance of differences among three or more groups. The null hypothesis states that k (3 or more) samples have been drawn from the same population or identical populations. Such a test is used when comparing three or more samples or conditions to determine whether there is an over-all difference among the k samples or conditions before any pair of samples is drawn to determine the significance of the difference between them. Only after we have rejected the null hypothesis by some k-sample test are we justified in testing any two of the k samples for significant differences. The parametric test used in testing to see if several samples are drawn from identical populations is the analysis of variance or F-test. However, we must assume that the data is drawn independently from normally distributed populations, the populations have the same variance, the means in the populations are linear combinations of effects due to rows and columns, and the variables are at least measured from an interval scale. Many times these assumptions cannot be realistically met. A nonparametric test for the case of k samples is the Friedman Two-Way Analysis of Variance by Ranks.

The Friedman Test is useful to test the null hypothesis that the k samples are drawn from the same population. The data are in at least an ordinal scale. If the k samples are matched, then in each sample there are the same number of cases. Matching can be achieved by placing the subject group under k conditions. Or there could be several sets with k matched subjects. The data is cast in a two-way table with N rows and k columns with the rows related to the various subjects or sets of subjects and the columns related to the various conditions. The data of this test is not the data values but the ranks of the data. The scores of each row are ranked separately from the others. Thus, the row ranks range from 1 to k. Therefore, the Friedman Test investigates whether it is conceivable that the different columns of ranks came from the same population. If the scores are independent of the conditions, then the sets of ranks in each column would be random and the column totals would be equal. Thus, we test to see if the rank totals are different. In the case of tie values in the row, assign the average ranks to the values. The test statistic value is as follows:

$$\chi_r^2 = \frac{12}{Nk(k+1)} \sum_{j=1}^{k} (R_j)^2 - 3N(k+1)$$

where N = the number of rows.

k = the number of columns.

R_j = sum of ranks in column j.

If N and/or k are not too small, then χ_r^2 is distributed approximately Chi-Square with (k-1) degrees of freedom.

For this program, the number of rows, N, is unlimited, but the number of columns, k, is restricted. (If System S, length of tape restricts N.)

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

The observations on the tape are arranged in groups called records. In this program, one row is a record. During entry, the record is written on the tape after the entire cell is entered and checked.

Because the tape has a fixed length, a maximum number of records can be written on it. Two lengths are available: 75 feet (Wang Part # 174-1250) and 150 feet (Wang Part # 174-1251). The program is designed for use of 150 foot tapes.

The length of a record depends on the number of columns. The maximum number of records on the tape cassette depends on the length of the record. If all the data cannot be stored on a single cassette, two or more cassettes are used. As the records are written, they are counted. When the maximum is reached, cassette changing messages are displayed (only one cassette for data is allowed in the System S).

As it is sold, the program contains the following maximum parameters:

System A: C = 21, 296 for the maximum number of records per cassette.

System S: C = 49, 147 for the maximum number of records per cassette.

Where C = # of columns.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of C:

   $5 * C \leq$ the number of variables available.

2. Select the appropriate value of C for your System from the following table:

CAPACITY	8K	12K	16K	20K
C for System A	21	124	226	255
C for System S	49	151	253	

3. Look up the maximum number of records per cassette (D') in the following table:

	24	52	80	108	136	164	192	220	248	255
75 feet	146	72	47	35	27	22	19	16	14	12
150 feet	296	147	97	72	57	47	40	35	31	27

*if your max is not listed, refer to the next highest increment.

NOTE:

In the System S, the number of records used is not checked against the number allowed. Remember not to exceed the table value or an error results.

4. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR and touch RETURN(EXEC).

5. Key LOAD "NPS116AA" for the System A or LOAD "NSS116AA" for the System S, and touch RETURN(EXEC).

6. Key LIST 170, touch RETURN(EXEC). The screen should display:

   System A: 170 DIM X(21),S(21),A(21),P(21),R(21):
   SELECT #110A,#210B:D=296:H=32

   System S: 170 DIM X(49),S(49),A(49),P(49),
   R(49):SELECT #110A:H=32

7. Rekey Statement 170 using the new maximum parameters:

   System A: 170 DIM X(C),S(C),A(C),P(C),R(C):
   SELECT #110A,#210B:D=D':H=32

   System S: 170 DIM X(C),S(C),A(C),P(C),R(C):
   SELECT #110A:H=32

   Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS116AA" for the System A, or "NSS116AA" for the System S, and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Use the Friedman Test on the following data table: k=10 N=3.

9	4	1	7	6	5	2	8	9	1
6	2	1	9	8	2	5	6	7	1
4	5	1	2	8	6	7	9	13	5

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS116AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). (For the System S, the program name is "NSS116AA".)
2. TEST INFORMATION ENTER PROJECT NAME ?----------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?----------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Use the Friedman Test on the following data table: k=10 N=3.

9	4	1	7	6	5	2	8	9	1
6	2	1	9	8	2	5	6	7	1
4	5	1	2	8	6	7	9	13	5

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

NOTE:

The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.

DISPLAYS	INSTRUCTIONS
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F160 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	7. Mount a scratch cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F160.)
8. INPUT PARAMETERS ENTER # OF ROWS ?_	8. The number of rows = 3, touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER # OF COLUMNS ?_	9. The number of columns = 10, touch RETURN(EXEC).
10. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 8.

Example

Use the Friedman Test on the following data table: k=10 N=3.

9	4	1	7	6	5	2	8	9	1
6	2	1	9	8	2	5	6	7	1
4	5	1	2	8	6	7	9	13	5

DISPLAYS	INSTRUCTIONS
	NOTE: The parameters are displayed for verification.
11. DATA INPUT FOR ROW #1, COLUMN 1 ENTER DATA VALUE ?_	11. Row 1, column 1 = 9, touch RETURN(EXEC).
12. DATA INPUT FOR ROW #1, COLUMN 2 ENTER DATA VALUE ?_	12. Row 1, column 2 = 4, touch RETURN(EXEC).

Enter all items in Row 1 of example.

13. CORRECTION ROUTINE FOR ROW # 1, ITEMS #1-10 IS DATA OK (Y OR N) ?-_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section IV.

NOTE:

Follow steps 11-13 to enter all rows. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN (EXEC). For System A only: the program is written to handle multi-volume files of data. The program contains a constant value that dictates the number of data records which can be stored per tape cassette. Once this number of records has been written, the volume is closed, and the following example instructions are displayed, after data cassette 1 has been rewound. (Note continued)

Example

Use the Friedman Test on the following data table: k=10 N=3.

9	4	1	7	6	5	2	8	9	1
6	2	1	9	8	2	5	6	7	1
4	5	1	2	8	6	7	9	13	5

DISPLAYS	INSTRUCTIONS
	a. REMOVE AND LABEL VOL 1 OF FILE NPS1F160 - UNIT 1 KEY RETURN(EXEC) TO RESUME. ?_ b. MOUNT SCRATCH VOL TO BECOME VOL 2 OF FILE NPS1F160 - UNIT 1 KEY RETURN(EXEC) TO RESUME. ?_
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F160 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette. touch RETURN(EXEC). (For the System S, the file name is NSS1F160.)
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?_ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	16. Enter an output device symbol and touch RETURN(EXEC).
17. MOUNT VOL 1 OF FILE NPS1F160 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F160.) NOTE: If Volume 1 already is in Unit 1 from the corrections routine, ignore this step which is repeated for all volumes in a multi-volume System A.

Example

Use the Friedman Test on the following data table: k=10 N=3.

9	4	1	7	6	5	2	8	9	1
6	2	1	9	8	2	5	6	7	1
4	5	1	2	8	6	7	9	13	5

DISPLAYS	INSTRUCTIONS
18a. INITIALIZATION	18a. The system now is initializing the column totals.
b. CREATING WORK AREAS	b. The system now is creating work areas. (Ths message appears for all rows.)
c. SORTING DATA	c. The system now is sorting the data. (This message appears for all rows.)
d. SETTING UP AVERAGE RANKS	d. The system now is setting up average ranks. (This mes- appears for all rows.)
e. ALIGNING AVERAGE RANKS	e. The system now is aligning average ranks. (This message appears for all rows.)
f. SUM OF COLUMN RANKS	f. The system now is calculating the sum of the column ranks. (This message appears for all rows.)
g. EXECUTING PROGRAM	g. The system now is executing The Friedman Two-Way Analysis of Variance by Ranks Test.
19. STOP END OF PROGRAM :_	19. The test results are displayed for verification.
	20. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 16.

Example

Use the Friedman Test on the following data table: k=10 N=3.

9	4	1	7	6	5	2	8	9	1
6	2	1	9	8	2	5	6	7	1
4	5	1	2	8	6	7	9	13	5

DISPLAYS	INSTRUCTIONS
B. MOUNT VOL 1 OF FILE NPS1F160 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F160. Go to Section II.)
C. ENTER # OF TAPE DRIVES (1 OR 2) ?_	C. Enter 1 or 2 and touch RETURN (EXEC). If 1, go to Section II. If 2, go to Section III.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. ROW # IN ERROR (0 IF END) ?_	A. Enter the row in error or 0 and touch RETURN(EXEC). If a row number is entered, go to the next step. If '0', go to step 15. NOTE: If the data file contains more than one volume, the program determines the location of the record and displays the appropriate volume to mount. See step B. For the System S, ignore step B.
B. MOUNT VOL 2 OF FILE NPS1F160 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated volume and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-10 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Step A of Section II. If 'N', go to Section IV.

Example

Use the Friedman Test on the following data table: k=10 N=3.

9	4	1	7	6	5	2	8	9	1
6	2	1	9	8	2	5	6	7	1
4	5	1	2	8	6	7	9	13	5

DISPLAYS	INSTRUCTIONS
	NOTE: Follow steps A-C for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION III
TWO TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. ROW # IN ERROR (0 IF END) ?_	A. Enter the row in error or 0 and touch RETURN(EXEC). If a row number is entered, go to the next step. If '0', go to step 15. NOTE: Row numbers must be entered sequentially.
B. MOUNT VOL 2 OF FILE NPS1F160 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated volume and touch RETURN(EXEC). NOTE: This prompt only appears when the row selected is not located in Volume 1.
C. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F160 - UNIT 2 KEY RETURN(EXEC) TO RESUME ?_	C. Mount a scratch cassette in Unit 2 and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-10 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section III. If 'N', go to Section IV.

Example

Use the Friedman Test on the following data table: k=10 N=3.

9	4	1	7	6	5	2	8	9	1
6	2	1	9	8	2	5	6	7	1
4	5	1	2	8	6	7	9	13	5

DISPLAYS	INSTRUCTIONS
	NOTE: Follow steps A-D for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION IV
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-10 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the item in error and touch RETURN(EXEC). NOTE: If the row selected contains only one item, ignore this step.
B. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-10 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC). NOTE: If proceeding from step 13, that step reappears; follow the appropriate operating instructions. If proceeding from either step C of Section II or Step D of Section III, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE BY RANKS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


   # OF ROWS =  3
# OF COLUMNS =  10


DATA INPUT/RANK VALUES:

ROW # 1
 9            4            1            7            6
 5            2            8            9            1

 9.5          4            1.5          7            6
 5            3            8            9.5          1.5

ROW # 2
 6            2            1            9            8
 2            5            6            7            1

 6.5          3.5          1.5          10           9
 3.5          5            6.5          8            1.5

ROW # 3
 4            5            1            2            8
 6            7            9            13           5

 3            4.5          1            2            8
 6            7            9            10           4.5



THE FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE BY RANKS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


   # OF ROWS =  3
# OF COLUMNS =  10


COLUMN TOTALS R(J):

 19           12           4            19           23
 14.5         15           23.5         27.5         7.5


SUM(R^2) =  3211


CHI-SQUARE =  17.7636363636
      D.F. =  9


END OF PROGRAM
```

CHAPTER XX THE CHI-SQUARE TEST FOR k INDEPENDENT SAMPLES

PROGRAM ABSTRACT

The program tests to determine whether k independent samples are drawn from the same population or k identical populations. The data is frequencies in discrete categories (nominal or ordinal).

PROGRAM DESCRIPTION

In the analysis of data from several independent samples, the researcher is always interested in testing to see if these samples could have conceivably come from the same population. However, sample data almost always differ somewhat, and the problem then is to determine if the observed differences are due to the differences between populations or are due to just chance variations. Thus, the null hypothesis under test is to determine whether k independent samples are drawn from the same population or from k identical populations. The usual parametric test is the one-way analysis of variance or F-test. However, we need to assume that the data values are drawn independently from normally distributed populations which have the same variance, and the measurement of the variable must be on at least an interval scale. However, these assumptions cannot be always met realistically. Therefore, we need a test which has relaxed assumptions. A nonparametric test which can be used is the χ^2 Test for k Independent Samples.

The χ^2 Test for k Independent Samples is just a continuation of the test for two independent samples. If the data has frequencies in discrete categories (nominal or ordinal), then the χ^2 Test is used to determine the significance of differences among the k independent samples.

The procedure in this program is to cast the frequencies (observed) into a (kxr) contingency table with k rows for the groups or samples. Then, the expected frequencies are determined for each cell by taking the product of the marginal totals common to the cell and dividing by N, where N is the sum of each group of marginal totals or the total number of independent observations. The table has the following form:

	1	2		r
1	O_{11}	O_{12}	...	O_{1r}
2	O_{21}	O_{22}	...	O_{2r}
⋮	⋮	⋮	⋱	⋮
k	O_{k1}	O_{k2}	...	O_{kr}

NOTE:

The table form denoted here is slightly different than from the text books. They have the table set up as (rxk). The reason for the use of (kxr) is this program has each sample read from a row rather than down a column.

To test the null hypothesis that the k samples do not differ among themselves, we use the following formula:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where O_{ij} = the observed frequency value in the ith row and jth column.

E_{ij} = the expected frequency value in the ith row and jth column.

r = the number of columns in the table.

k = the number of rows in the table, the number of samples.

The sampling distribution of χ^2 can be shown if necessary to be approximately Chi-Square with (k-1)(r-1) degrees of freedom. Thus, for significance, we can use a Chi-Square table.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statements 180 and 190 of the program. By changing Statements 180 and 190, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

The observations on the tape are arranged in groups called records. In this program, one row is a record. During entry, the record is written on the tape after the entire cell is entered and checked.

Because the tape has a fixed length, a maximum number of records can be written on it. Two lengths are available: 75 feet (Wang Part #174-1250) and 150 feet (Wang Part # 174-1251). The program is designed for use of 150 foot tapes.

The length of a record depends on the number of columns. The maximum number of records on the tape cassette depends on the length of the record. If all the data cannot be stored on a single cassette, two or more cassettes are used. As the records are written, they are counted. When the maximum is reached, cassette changing messages are displayed (only one cassette for data is allowed in the System S).

As it is sold, the program contains the following maximum parameters:

System A: C = 76, 97 for the maximum number of records per cassette.

System S: C = 147, 47 for the maximum number of records per cassette.

Where C = number of columns.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of C:

   $2 * C \leq$ the number of variables available.

2. Select the appropriate value of C for your system from the following table:

CAPACITY	8K	12K
C for System A	76	255
C for System S	147	255

3. Look up the maximum number of records per cassette (D') in the following table:

	24	52	80	108	136	164	192	220	248	255
75 feet	146	72	47	35	27	22	19	16	14	12
150 feet	296	147	97	72	57	47	40	35	31	27

*if your max is not listed, refer to the next highest increment.

> NOTE:
>
> In the System S, the number of records used is not checked against the number allowed. Remember not to exceed the table value or an error results.

4. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR and RETURN(EXEC).

5. Key LOAD "NPS117AA" for the System A or LOAD "NSS117AA" for the System S, and touch RETURN(EXEC).

6. Key LIST 180, and touch RETURN(EXEC). The screen should display:

```
System A: 180 DIM X(76),C(76)
          190 SELECT #110A,#210B:D=97:H=32

System S: 180 DIM X(147),C(147):
          SELECT #110A
```

7. Rekey Statements 180 and 190 using the new maximum parameters:

```
System A: 180 DIM X(C),C(C)
          190 SELECT #110A,#210B:D=D':H=32

System S: 180 DIM X(C),C(C):
          SELECT #110A
```

   Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS117AA" for the System A, or "NSS117AA" for the System S, and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Given 4 samples of 5 elements each, test using the χ^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS117AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). (For the System S, the program name is "NSS117AA".)
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN (EXEC).

Example

Given 4 samples of 5 elements each, test using the χ^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F170 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	7. Mount a scratch cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F170.)
8. INPUT PARAMETERS ENTER # OF ROWS ?_	8. The number of rows = 4, touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER # OF COLUMNS ?_	9. The number of columns = 5, touch RETURN(EXEC).
10. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 8.

Example

Given 4 samples of 5 elements each, test using the x^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
	NOTE: The parameters are displayed for verification.
11. DATA INPUT FOR ROW #1, COLUMN 1 ENTER OBSERVED VALUE ?_	11. Row 1, column 1 = 22, touch RETURN(EXEC).
12. DATA INPUT FOR ROW #1, COLUMN 2 ENTER OBSERVED VALUE ?_	12. Row 1, column 2 = 39, touch RETURN(EXEC).

Enter all items in Row 1 of example.

DISPLAYS	INSTRUCTIONS
13. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-5 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section IV.

NOTE:

Follow steps 11-13 for all rows. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

For System A only: The program is written to handle multi-volume files of data. The program contains a constant value that dictates the number of data records which can be stored per tape cassette. Once this number of records has been written, the volume is closed, and the following example instructions are displayed, after data cassette 1 has been rewound. (Note continued)

Example

Given 4 samples of 5 elements each, test using the x^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
	a. REMOVE AND LABEL VOL 1 OF FILE NPS1F170 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_ b. MOUNT SCRATCH VOL TO BECOME VOL 2 OF FILE NPS1F170 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F170 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC). (For the System S, the file name is NSS1F170.)
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?-- FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	16. Enter an output device symbol and touch RETURN(EXEC).
17. MOUNT VOL 1 OF FILE NPS1F170 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F170.)

Example

Given 4 samples of 5 elements each, test using the X^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
	NOTE: If Volume 1 already is in Unit 1 from the corrections routine, ignore this step which is repeated for all volumes in a multi-volume System A.
18a. COMPUTING COLUMN TOTALS	18a. The system now is computing the column totals.
b. EXECUTING PROGRAM	b. The system now is executing the Chi-Square Test for k Independent Samples.
19. STOP END OF PROGRAM :_	19. The test results are displayed for verification.
	20. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 16.
B. MOUNT VOL 1 OF FILE NPS1F170 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F170. Go to Section II.)

Example

Given 4 samples of 5 elements each, test using the χ^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
C. ENTER # OF TAPE DRIVES (1 OR 2) ?_	C. Enter 1 or 2 and touch RETURN (EXEC). If 1, go to Section II. If 2, go to Section III.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. ROW # IN ERROR (0 IF END) ?_	A. Enter the row in error or 0 and touch RETURN(EXEC). If a row number is entered, go to the next step. If '0', go to step 15. NOTE: If the data file has more than one volume, the program determines the location of the record and displays the appropriate volume to mount. See step B. For System S, ignore step B.
B. MOUNT VOL 2 OF FILE NPS1F170 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated volume and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-5 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section II. If 'N', go to Section IV.

Example

Given 4 samples of 5 elements each, test using the x^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
	NOTE: Follow steps A-C for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION III
TWO TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. ROW # IN ERROR (0 IF END) ?_	A. Enter the row in error or 0 and touch RETURN(EXEC). If a row number is entered, go to the next step. If '0', go to step 15. NOTE: Row numbers must be entered sequentially.
B. MOUNT VOL 2 OF FILE NPS1F170 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated volume and touch RETURN(EXEC). NOTE: This prompt appears only when the row selected is not located in Volume 1.
C. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F170 - UNIT 2 KEY RETURN(EXEC) TO RESUME ?_	C. Mount a scratch cassette in Unit 2 and touch RETURN(EXEC).

Example

Given 4 samples of 5 elements each, test using the x^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
D. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-5 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section III. If 'N', go to Section IV. NOTE: Follow steps A-D for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION IV
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-5 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the item in error and touch RETURN(EXEC). NOTE: If the row selected contains only one item, ignore this step.

Example

Given 4 samples of 5 elements each, test using the x^2 test.

	1	2	3	4	5
1	22	39	1	15	9
2	74	13	106	10	22
3	3	6	5	18	29
4	16	33	8	23	7

DISPLAYS	INSTRUCTIONS
B. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-5 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC).

NOTE:

If proceeding from step 13, that step reappears; follow the appropriate operating instructions. If proceeding from either step C of Section II or step D of Section III, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE CHI-SQUARE TEST FOR K INDEPENDENT SAMPLES
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


   # OF ROWS =  4
# OF COLUMNS =  5


INPUT DATA:

ROW # 1
 22         39         1          15         9

ROW # 2
 74         13         106        10         22

ROW # 3
 3          6          5          18         29

ROW # 4
 16         33         8          23         7
```

THE CHI-SQUARE TEST FOR K INDEPENDENT SAMPLES
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

\# OF ROWS = 4
\# OF COLUMNS = 5

I	J	O(I, J)	E(I, J)	X(I, J)
1	1	22.0000	21.546840958	0.009530544
1	2	39.0000	17.050108932	28.257750128
1	3	1.0000	22.483660130	20.528136874
1	4	15.0000	12.366013071	0.561044784
1	5	9.0000	12.553376906	1.005823973
2	1	74.0000	56.372549019	5.512027280
2	2	13.0000	44.607843137	22.396414565
2	3	106.0000	58.823529411	37.835529412
2	4	10.0000	32.352941176	15.443850267
2	5	22.0000	32.843137254	3.579853672
3	1	3.0000	15.283224400	9.872105370
3	2	6.0000	12.093681917	3.070442861
3	3	5.0000	15.947712418	7.515335369
3	4	18.0000	8.771241830	9.710138998
3	5	29.0000	8.904139433	45.354592088
4	1	16.0000	21.797385620	1.541913357
4	2	33.0000	17.248366013	14.384781322
4	3	8.0000	22.745098039	9.558891142
4	4	23.0000	12.509803921	8.796637777
4	5	7.0000	12.699346405	2.557812694

THE CHI-SQUARE TEST FOR K INDEPENDENT SAMPLES
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

\# OF ROWS = 4
\# OF COLUMNS = 5

CHI-SQUARE = 247.4926124845
D.F. = 12

END OF PROGRAM

CHAPTER XXI THE EXTENSION OF THE MEDIAN TEST (MEDIAN KNOWN)

PROGRAM ABSTRACT

This program version assumes that the median is known. It tests to determine whether k independent samples are drawn from the same population or from populations with equal medians. The samples may be of unequal size. The variable is measured in at least an ordinal scale.

PROGRAM DESCRIPTION

In the analysis of data from several independent samples, the researcher is always interested in testing to see if these samples could have conceivably come from the same population. However, sample data almost always differ somewhat, and the problem then is to determine if the observed differences are due to the differences between populations or are due to just chance variations. Thus, the null hypothesis under test is to determine whether k independent samples are drawn from the same population or from k identical populations. The usual parametric test is the one-way analysis of variance or F-test. However, we need to assume that the data values are drawn independently from normally distributed populations which have the same variance, and the measurement of the variable must be on at least an interval scale. However, these assumptions cannot be always met realistically. Therefore, we need a test which has relaxed assumptions. A nonparametric test which can be used is the Extension of the Median Test.

This particular program version of the Median Test assumes that the median is known. The test determines whether k independent samples (may be of unequal sizes) are drawn from the same population or from populations with equal medians. It is useful for variables measured in at least an ordinal scale.

The procedure is to accumulate for each sample two frequency values: the number of values above the median and the number less than or equal to the median. This is done for all k samples and the resulting frequencies are placed in a 2 x k table.

	1	2		k
Data > M_D	O_{11}	O_{12}	. . .	O_{1k}
Data $\leq M_D$	O_{21}	O_{22}	. . .	O_{2k}

To test the null hypothesis that the k samples come from the same population or populations with equal medians, we then compute the expected frequencies for each cell in the table and compute the χ^2 value using the following formula:

$$\chi^2 = \sum_{i=1}^{2} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where O_{ij} = the observed frequency in the ith row and jth column.

E_{ij} = the expected frequency in the ith row and jth column.

k = the number of columns, the number of samples.

It can be shown that the sampling distribution of χ^2 is approximately Chi-Square with (k-1) degrees of freedom. Thus, for significance values, we can use a Chi-Square table.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 180 of the program. By changing Statement 180, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

After information is temporarily stored internally in the System 2200, it is stored permanently on a tape cassette. When the system is turned off, information stored in the system is lost, but information stored on the tape cassette remains intact.

The observations on the tape are arranged in groups called records. In this program, one sample is a record. During entry, the record is written on the tape after the entire cell is entered and checked.

Because the tape has a fixed length, a maximum number of records can be written on it. Two lengths are available: 75 feet (Wang Part # 174-1250) and 150 feet (Wang Part # 174-1251). The program is designed for use of 150 foot tapes.

The length of a record depends on the maximum sample size. The maximum number of records on the tape cassette depends on the length of the record. If all the data cannot be stored on a single cassette, two or more cassettes are used. As the records are written, they are counted. When the maximum is reached, cassette changing messages are displayed (only one cassette for data is allowed in the System S).

As it is sold, the program contains the following maximum parameters:

System A: N = 90, R = 23, 72 for the maximum number of records per cassette.

System S: N = 90, R = 90, 72 for the maximum number of records per cassette.

Where N = maximum sample size.
R = number of samples.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of N and R:

   $N + (2 * R) \leq$ the number of variables available (C).

2. Calculate the maximum N, R, using the appropriate value of C for your system from the following table:

CAPACITY	8K	12K	16K
C for System A	137	649	1161
C for System S	271	782	

3. Look up the maximum number of records per cassette (D') in the following table:

	24	52	80	108	136	164	192	220	248	255
75 feet	146	72	47	35	27	22	19	16	14	12
150 feet	296	147	97	72	57	47	40	35	31	27

*if your max is not listed, refer to the next highest increment.

> NOTE:
>
> In the System S, the number of records used is not checked against the number allowed. Remember not to exceed the table value or an error results.

4. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR and RETURN(EXEC).

5. Key LOAD "NPS118AA" for the System A or LOAD "NSS118AA" for the System S, and touch RETURN(EXEC).

6. Key LIST 180, and touch RETURN(EXEC). The screen should display:

```
System A: 180 DIM X(90),T(2,23):
          SELECT #110A,#210B:D=72:H=32

System S: 180 DIM X(90),T(2,90):
          SELECT #110A
```

7. Rekey Statement 180, using the new maximum parameters:

```
System A: 180 DIM X(N),T(2,R):
          SELECT #110A,#210B:D=D':H=32

System S: 180 DIM X(N),T(2,R):
          SELECT #110A
```

   Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS118AA" for the System A, or 'NSS118AA" for the System S, and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

$m = 3.5$

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS118AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). (For the System S, the program name is "NSS118AA".)
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

m = 3.5

DISPLAYS	INSTRUCTIONS
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed, if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?-	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F180 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	7. Mount a scratch cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F180.)
8. INPUT PARAMETERS ENTER # OF SAMPLES ?_	8. The number of samples = 6, touch RETURN(EXEC).

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

m = 3.5

DISPLAYS	INSTRUCTIONS
9. INPUT PARAMETERS ENTER MEDIAN VALUE ?_	9. The median value = 3.5, touch RETURN(EXEC).
10. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 8. NOTE: The parameters are displayed for verification.
11. INPUT SAMPLE SIZE FOR SAMPLE 1 ENTER SAMPLE SIZE ?_	11. Sample 1 = 4, touch RETURN (EXEC).
12. INPUT SAMPLE SIZE FOR SAMPLE 1 SAMPLE SIZE OK (Y OR N) ?_	12. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 11. NOTE: The sample size is displayed for verification.
13. DATA INPUT FOR SAMPLE 1, ITEM #1 ENTER DATA VALUE ?_	13. Sample 1, item 1=3, touch RETURN(EXEC).
14. DATA INPUT FOR SAMPLE 1, ITEM #2 ENTER DATA VALUE ?_	14. Sample 1, item 2=7, touch RETURN(EXEC).

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

m = 3.5

DISPLAYS	INSTRUCTIONS

Enter all items in Sample 1 of example.

DISPLAYS	INSTRUCTIONS
15. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section IV.

NOTE:

Follow steps 11-15 for all samples. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

For System A only: the program is written to handle multi-volume files of data. The program contains a constant value that dictates the number of data records which can be stored per tape cassette. Once this number of records has been written, the volume is closed, and the following example instructions are displayed, after data cassette 1 has been rewound.

a. REMOVE AND LABEL VOL 1 OF FILE NPS1F180 - UNIT 1
KEY RETURN(EXEC) TO RESUME
?_

(Note continued)

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

m = 3.5

DISPLAYS	INSTRUCTIONS
	b. MOUNT SCRATCH VOL TO BECOME VOL 2 OF FILE NPS1F180 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_
16. REMOVE AND LABEL VOL 1 OF FILE NPS1F180 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	16. After labeling the cassette, touch RETURN(EXEC). (For the System S, the file name is NSS1F180.)
17. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	17. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 21.
18. ENTER OUTPUT DEVICE TYPE SYMBOL ?-- FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	18. Enter an output device symbol and touch RETURN(EXEC).
19. MOUNT VOL 1 OF FILE NPS1F180 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	19. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F180.) NOTE: If Volume 1 already is in Unit 1 from the corrections routine, ignore this step which is repeated for all volumes in a multi-volume System A.

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

m = 3.5

DISPLAYS	INSTRUCTIONS
20. EXECUTING PROGRAM	20. The system now is executing the Extension of the Median Test (median known).
21. STOP END OF PROGRAM :_	21. The test results are displayed for verification.
	22. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 18.
B. MOUNT VOL 1 OF FILE NPS1F180 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F180. Go to Section II.)
C. ENTER # OF TAPE DRIVES (1 OR 2) ?_	C. Enter 1 or 2 and touch RETURN (EXEC). If 1, go to Section II. If 2, go to Section III.

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

m = 3.5

DISPLAYS	INSTRUCTIONS

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. SAMPLE # IN ERROR (0 IF END) ?_	A. Enter the sample in error or 0 and touch RETURN(EXEC). If a sample number is entered, go to the next step. If '0', go to step 17. NOTE: If the data file has more than one volume, the program determines the location of the record and displays the appropriate volume to mount. See Step B. For System S, ignore Step B.
B. MOUNT VOL 2 OF FILE NPS1F180 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section II. If 'N', go to Section IV. NOTE: Follow steps A-C for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

m = 3.5

DISPLAYS	INSTRUCTIONS

SECTION III
TWO TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. SAMPLE # IN ERROR (0 IF END) ?_	A. Enter the sample in error or 0 and touch RETURN(EXEC). If a sample number is entered, go to the next step. If '0', go to step 17. NOTE: Sample numbers must be entered sequentially.
B. MOUNT VOL 2 OF FILE NPS1F180 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). NOTE: This prompt appears only when the sample selected is not located in Volume 1.
C. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F180 - UNIT 2 KEY RETURN(EXEC) TO RESUME ?_	C. Mount a scratch cassette in Unit 2 and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section III. If 'N', go to Section IV.

Example

Given the Median for 6 samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10	11	12
1	3	7	3.5	1								
2	3	1	5	4	9	1	6	3	2	8	7	6
3	5	4	1	8	2	3	1	4	6	2		
4	3.5	5	6	3	1							
5	5	3.5	2	7	4	1	3	6	2	3	2	
6	10	3.5	5	3.5	4	3.5						

m = 3.5

DISPLAYS	INSTRUCTIONS
	NOTE: Follow steps A-D for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION IV
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the items in error and touch RETURN (EXEC). NOTE: If the sample selected contains only one item, ignore this step.
B. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC). NOTE: Follow steps A-B for all samples. If proceeding from step 15, that step reappears; follow the appropriate operating instructions. If proceeding from either step C of Section II or step D of Section III, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE EXTENSION OF THE MEDIAN TEST (MEDIAN KNOWN)
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF SAMPLES =  6
      MEDIAN =  3.5


INPUT DATA:

SAMPLE 1 , SIZE =  4
 3               7               3.5             1

SAMPLE 2 , SIZE =  12
 3               1               5               4               9
 1               6               3               2               8
 7               6

SAMPLE 3 , SIZE =  10
 5               4               1               8               2
 3               1               4               6               2


SAMPLE 4 , SIZE =  5
 3.5             5               6               3               1


SAMPLE 5 , SIZE =  11
 5               3.5             2               7               4
 1               3               6               2               3
 2

SAMPLE 6 , SIZE =  6
 10              3.5             5               3.5             4
 3.5



THE EXTENSION OF THE MEDIAN TEST (MEDIAN KNOWN)
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF SAMPLES =  6
      MEDIAN =  3.5


      I     J          O(I,J)             E(I,J)               X(I,J)

      1     1          1.0000          1.833333333           0.378787878
      2     1          3.0000          2.166666666           0.320512820
      1     2          7.0000          5.500000000           0.409090909
      2     2          5.0000          6.500000000           0.346153846
      1     3          5.0000          4.583333333           0.037878787
      2     3          5.0000          5.416666666           0.032051282
      1     4          2.0000          2.291666666           0.037121212
      2     4          3.0000          2.708333333           0.031410256
      1     5          4.0000          5.041666666           0.215220385
      2     5          7.0000          5.958333333           0.182109557
      1     6          3.0000          2.750000000           0.022727272
      2     6          3.0000          3.250000000           0.019230769
```

```
THE EXTENSION OF THE MEDIAN TEST (MEDIAN KNOWN)
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF SAMPLES =  6
      MEDIAN =  3.5


CHI-SQUARE =  2.032294977725
      D.F.  =  5


END OF PROGRAM
```

CHAPTER XXII THE EXTENSION OF THE MEDIAN TEST (MEDIAN UNKNOWN)

PROGRAM ABSTRACT

This program version assumes that the median is unknown and must be determined. It tests to determine whether k independent samples are drawn from the same population or from populations with equal medians. The samples may be of unequal size. The variable is measured in at least an ordinal scale.

PROGRAM DESCRIPTION

In the analysis of data from several independent samples, the researcher is always interested in testing to see if these samples could have conceivably come from the same population. However, sample data almost always differ somewhat, and the problem then is to determine if the observed differences are due to the differences between populations or are due to just chance variations. Thus, the null hypothesis under test is to determine whether k independent samples are drawn from the same population or from k identical populations. The usual parametric test is the one-way analysis of variance or F-test. However, we need to assume that the data values are drawn independently from normally distributed populations which have the same variance, and the measurement of the variable must be on at least an interval scale. However, these assumptions cannot be always met realistically. Therefore, we need a test which has relaxed assumptions. A nonparametric test which can be used is the Extension of the Median Test.

This particular version of the Median Test assumes that the median is unknown and must be determined in the program. The test determines whether k independent samples (may be of unequal sizes) are drawn from the same population or populations with equal medians. It is useful for variables measured in at least an ordinal scale.

The procedure is to first determine the median score for the combined k samples of data. Then we accumulate for each sample two values or frequencies: the number of values above the median and the number less than or equal to the median. This is done for all k samples. Then the resulting frequencies are placed in a 2 x k table.

	1	2		k
DATA > M_D	O_{11}	O_{12}	. . .	O_{1k}
DATA $\leq$ M_D	O_{21}	O_{22}	. . .	O_{2k}

To test the null hypothesis, we compute the expected frequencies for each cell in the table and then compute the x^2 value using the following formula:

$$\chi^2 = \sum_{i=1}^{2} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where O_{ij} = the observed frequency in the ith row and jth column.

E_{ij} = the expected frequency in the ith row and jth column.

k = the number of columns, the number of samples.

It can be shown that the sampling distribution of χ^2 is approximately Chi-Square with (k-1) degrees of freedom. Thus, for significance values, we can use a Chi-Square table.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 180 of the program. By changing Statement 180, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

After information is temporarily stored internally in the System 2200, it is stored permanently on a tape cassette. When the system is turned off, information stored in the system is lost, but information stored on the tape cassette remains intact.

The observations on the tape are arranged in groups called records. In this program, one sample is a record. During entry, the record is written on the tape after the entire cell is entered and checked.

Because the tape has a fixed length, a maximum number of records can be written on it. Two lengths are available: 75 feet (Wang Part # 174-1250) and 150 feet (Wang Part # 174-1251). The program is designed for use of 150 foot tapes.

The length of a record depends on the sample size. The maximum number of records on the tape cassette depends on the length of the record. If all the data cannot be stored on a single cassette, two or more cassettes are used. As the records are written, they are counted. When the maximum is reached, cassette changing messages are displayed (only one cassette for data is allowed in the System S).

As it is sold, the program contains the following maximum parameters:

System A: N = 10, C = 70, R = 7, 296 for the maximum number of records per cassette.

System S: N = 18, C = 196, R = 11, 296 for the maximum number of records per cassette.

Where N = maximum sample size.
C = total combined sample.
R = # of samples.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the values of N, R, and C:

$$N + C + (2 * R) \leq \text{the number of variables available (E).}$$

2. Calculate the maximum N, R, C, using the appropriate value of E for your system from the following table:

CAPACITY	8K	12K	16K
E for System A	99	611	1123
E for System S	240	752	1264

3. Look up the maximum number of records per cassette (D') in the following table:

	24	52	80	108	136	164	192	220	248	255
75 feet	146	72	47	35	27	22	19	16	14	12
150 feet	296	147	97	72	57	47	40	35	31	27

*if your max is not listed, refer to the next highest increment.

NOTE:

In the System S, the number of records used is not checked against the number allowed. Remember not to exceed the table value or an error results.

4. Insert System Tape #2 into Unit 1 (on the Console), close the door and press REWIND.

5. Key LOAD "NPS119AA" for the System A or LOAD "NSS119AA" for the System S, and touch RETURN(EXEC).

6. Key LIST 180 and touch RETURN(EXEC). The screen should display:

   System A: 180 DIM X(10),S(70),T(2,7):SELECT
   #110A,#210B:D=296:H=32

   System S: 180 DIM X(18),S(196),T(2,11)
   190 SELECT #110A:H=32

7. Rekey Statement 180, using the new maximum parameters:

   System A: 180 DIM X(N),S(C),T(2,R):SELECT
   #110A,#210B:D=D':H=32

   System S: 180 DIM X(N),S(C),T(2,R)
   190 SELECT #110A:H=32

   Touch RETURN(EXEC)

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS119AA" for the System A, or "NSS119AA" for the System S, and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN (EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS119AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). (For System S, the program name is "NSS119AA".)
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?-	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	7. Mount a scratch cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F190.)
8. INPUT PARAMETER ENTER # OF SAMPLES ?_	8. The number of samples = 6, touch RETURN(EXEC).
9. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?-	9. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 8.

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS
	NOTE: The parameter is displayed for verification.
10. INPUT SAMPLE SIZE FOR SAMPLE 1 ENTER SAMPLE SIZE ?_	10. Sample 1 = 4, touch RETURN (EXEC).
11. INPUT SAMPLE SIZE FOR SAMPLE 1 SAMPLE SIZE OK (Y OR N) ?_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 10.
	NOTE: The sample size is displayed for verification.
12. DATA INPUT FOR SAMPLE 1, ITEM #1 ENTER DATA VALUE ?_	12. Sample 1, item 1=3, touch RETURN(EXEC).
13. DATA INPUT FOR SAMPLE 1, ITEM #2 ENTER DATA VALUE ?_	13. Sample 1, item 2=7, touch RETURN(EXEC).

Enter all items in Sample 1 of example.

DISPLAYS	INSTRUCTIONS
14. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	14. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 10. If 'N', go to Section IV.

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS
	NOTE: Follow steps 10-14 to enter all samples. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC). For System A only: The program is written to handle multi-volume files of data. The program contains a constant value that dictates the number of data records which can be stored per tape cassette. Once this number of records has been written, the volume is closed, and the following example instructions are displayed, after data cassette 1 has been rewound. a. REMOVE AND LABEL VOL 1 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_ b. MOUNT SCRATCH VOL TO BECOME VOL 2 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_
15. REMOVE AND LABEL VOL 1 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	15. After labeling the cassette, touch RETURN(EXEC). (For the System S, the file name is NSS1F190.)

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS
16. DO YOU WISH TO EXECUTE PROGRAM (Y OR N). ?_	16. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 20.
17. ENTER OUTPUT DEVICE TYPE SYMBOL ?_ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	17. Enter an output device symbol and touch RETURN(EXEC).
18. MOUNT VOL 1 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	18. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F190.) NOTE: If Volume 1 already is in Unit 1 from the corrections routine, ignore this step which is repeated for all volumes in a multi-volume System A.
19a. COMPUTE MEDIAN VALUE	19a. The system now is computing the median value.
b. EXECUTING PROGRAM	b. The system now is executing the Extension of the Median Test (median unknown).
20. STOP END OF PROGRAM :_	20. The test results are displayed for verification.

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS
	21. To rerun the test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

DISPLAYS	INSTRUCTIONS
A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 17.
B. MOUNT VOL 1 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F190. Go to Section II.)
C. ENTER # OF TAPE DRIVES (1 OR 2) ?_	C. Enter 1 or 2 and touch RETURN (EXEC). If 1, go to Section II. If 2, go to Section III.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. SAMPLE # IN ERROR (0 IF END) ?_	A. Enter the sample in error or 0 and touch RETURN(EXEC). If a sample number is entered, go to the next step. If '0', go to step 16.

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS
	NOTE: If the data file has more than one volume, the program determines the location of the record and displays the appropriate volume to mount; see step B. For System S, ignore Step B.
B. MOUNT VOL 2 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section II. If 'N', go to Section IV.
	NOTE: Follow steps A-C for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS

SECTION III
TWO TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. SAMPLE # IN ERROR (0 IF END) ?_	A. Enter the sample in error or 0 and touch RETURN(EXEC). If a sample number is entered, go to the next step. If '0', go to step 16. NOTE: Sample numbers must be entered sequentially.
B. MOUNT VOL 2 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). NOTE: This prompt appears only when the sample selected is not located in Volume 1.
C. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F190 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	C. Mount a scratch cassette and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section III. If 'N', go to Section IV.

Example

Not given the Median for the samples, use the Median Test for the following data:

	1	2	3	4	5	6	7	8	9	10
1	3	7	3.5	1						
2	3	1	5	4	9	1	6	3	2	8
3	5	4	1	8	2	3	1	4	6	2
4	3.5	5	6	3	1					
5	5	3.5	2	7	4	1	3	6	2	3
6	10	3.5	5	3.5	4	3.5				

DISPLAYS	INSTRUCTIONS
	NOTE: Follow steps A-D for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION IV
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the sample in error and touch RETURN(EXEC). NOTE: If the sample selected contains only one item, ignore this step.
B. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC). NOTE: Follow steps A and B for all samples. If proceeding from step 14, that step reappears; follow the appropriate operating instructions. If proceeding from either step C of Section II or step D of Section III, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE EXTENSION OF THE MEDIAN TEST (MEDIAN UNKNOWN)
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF SAMPLES =  6


INPUT DATA:

SAMPLE 1 , SIZE =  4
 3             7              3.5            1

SAMPLE 2 , SIZE =  10
 3             1              5              4              9
 1             6              3              2              8


SAMPLE 3 , SIZE =  10
 5             4              1              8              2
 3             1              4              6              2


SAMPLE 4 , SIZE =  5
 3.5           5              6              3              1


SAMPLE 5 , SIZE =  10
 5             3.5            2              7              4
 1             3              6              2              3


SAMPLE 6 , SIZE =  6
 10            3.5            5              3.5            4
 3.5

THE EXTENSION OF THE MEDIAN TEST (MEDIAN UNKNOWN)
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE. 4/2/75


# OF SAMPLES =  6
```

I	J	O(I, J)	E(I, J)	X(I, J)
1	1	1.0000	1.777777777	0.340277777
2	1	3.0000	2.222222222	0.272222222
1	2	5.0000	4.444444444	0.069444444
2	2	5.0000	5.555555555	0.055555555
1	3	5.0000	4.444444444	0.069444444
2	3	5.0000	5.555555555	0.055555555
1	4	2.0000	2.222222222	0.022222222
2	4	3.0000	2.777777777	0.017777777
1	5	4.0000	4.444444444	0.044444444
2	5	6.0000	5.555555555	0.035555555
1	6	3.0000	2.666666666	0.041666666
2	6	3.0000	3.333333333	0.033333333

```
THE EXTENSION OF THE MEDIAN TEST (MEDIAN UNKNOWN)
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF SAMPLES =  6


    MEDIAN =  3.5

CHI-SQUARE =  1.057500000006
      D.F. =  5


END OF PROGRAM
```

CHAPTER XXIII THE KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE BY RANKS TEST

PROGRAM ABSTRACT

The program tests to see if k independent samples are from different populations. The test assumes that the variable has a continuous distribution and is measured on at least an ordinal scale.

PROGRAM DESCRIPTION

In the analysis of data from several independent samples, the researcher is always interested in testing to see if these samples could have conceivably come from the same population. However, sample data almost always differ somewhat, and the problem then is to determine if the observed differences are due to the differences between populations or are due to just chance variations. Thus, the null hypothesis under test is to determine whether k independent samples are drawn from the same population or from k identical populations. The usual parametric test is the one-way analysis of variance or F-test. However, we need to assume that the data values are drawn independently from normally distributed populations which have the same variance, and the measurement of the variable must be on at least an interval scale. However, these assumptions cannot be always met realistically. Therefore, we need a test which has relaxed assumptions. A nonparametric test which can be used is the Kruskal-Wallis One-Way Analysis of Variance by Ranks.

The Kruskal-Wallis Test is extremely useful in determining if k independent samples are from different populations. Samples differ somewhat naturally. Thus, when testing for sample differences, we must determine if it is genuine population differences or chance variations. The null hypothesis tested is that the k samples come from the same population or from identical populations with respect to averages. The test assumes the variable has a continuous distribution and that it is measured on at least an ordinal scale.

The procedure is to combine all k samples into one group of N observations, rank the group, and then sum the ranks of each sample. The test determines whether these rank sums are so disparate that they are likely not to come from samples drawn from the same population. The following formula is used:

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \frac{R_j^2}{n_j} - 3(N+1)$$

where k = number of samples.

n_j = jth sample size.

N = total number of cases in all samples combined.

R_j = sum of ranks in jth sample (column).

It can be shown that H is distributed approximately Chi-Square with (k-1) degrees of freedom for sufficiently large sample sizes. In the case of tied observations, the mean of the ranks involved are assigned. Also a correction term is needed in the formula.

$$H = \frac{\frac{12}{N(N+1)} \sum_{j=1}^{k} \frac{R_j^2}{n_j} - 3(N+1)}{1 - \frac{\Sigma T}{N^3 - N}}$$

where $T = t^3 - t$ (where t is the number of tied values in a tied group of scores). The correction term increases the value of H and the results are more significant.

To determine significance, the value k and the sample sizes determine the method used. If k = 3 and the sample sizes are all less than or equal to 5, we use a table of critical values. For all other cases, we use a Chi-Square table with (k-1) degrees of freedom.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

After information is temporarily stored internally in the System 2200, it is stored permanently on a tape cassette. When the system is turned off, information stored in the system is lost, but information stored on the tape cassette remains intact.

The observations on the tape are arranged in groups called records. In this program, one sample is a record. During entry, the record is written on the tape after the entire cell is entered and checked.

Because the tape has a fixed length, a maximum number of records can be written on it. Two lengths are available: 75 feet (Wang Part # 174-1250) and 150 feet (Wang Part # 174-1251). The program is designed for use of 150 foot tapes.

The length of a record depends on the sample size. The maximum number of records on the tape cassette depends on the length of the record. If all the data cannot be stored on a single cassette, two or more cassettes are used. As the records are written, they are counted. When the maximum is reached, cassette changing messages are displayed (only one cassette for data is allowed in the System S).

As it is sold, the program contains the following maximum parameters:

System A: N = 4, A = 12, R = 3, 296 for the maximum number of records per cassette.

System S: N = 11, A = 44, R = 4, 296 for the maximum number of records per cassette.

Where N = sample size.
A = total combined sample.
R = number of samples.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of E:

$$N + (4*A) + R \leq \text{the number of variables available (E).}$$

2. Calculate the maximum N, A, R, using the appropriate value of E for your system from the following table:

CAPACITY	8K	12K	16K	20K
E for System A	60	572	1084	1596
E for System S	192	704	1216	

3. Look up the maximum number of records per cassette (D') in the following table:

	24	52	80	108	136	164	192	220	248	255
75 feet	146	72	47	35	27	22	19	16	14	12
150 feet	296	147	97	72	57	47	40	35	31	27

*if your max is not listed, refer to the next highest increment.

NOTE:

In the System S, the number of records used is not checked against the number allowed. Remember not to exceed the table value or an error results.

4. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR and RETURN(EXEC).

5. Key LOAD "NPS120AA" for the System A or LOAD "NSS120AA" for the System S, and touch RETURN(EXEC).

6. Key LIST 170, and touch RETURN(EXEC). The screen should display:

   System A: 170 DIM X(4),D(12),S(12),A(12),P(12),R(3):
   SELECT #110A,#210B:D=296:H=32

   System S: 170 DIM X(11),D(44),S(44),A(44),
   P(44),R(4):SELECT #110A:H=32

7. Rekey Statement 170, using the new maximum parameters:

   System A: 170 DIM X(N),D(A),S(A),A(A),P(A),R(R):
   SELECT #110A,#210B:D=D':H=32

   System S: 170 DIM X(N),D(A),S(A),A(A),P(A),R(R):
   SELECT #110A:H=32

   Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS120AA" for the System A, or "NSS120AA" for the System S, and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Run the Kruskal-Wallis Test on the following samples of data: $n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS120AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). (For the System S, the program name is "NSS120AA".)
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Run the Kruskal-Wallis Test on the following samples of data:

$n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' or STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F200 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	7. Mount a scratch cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F200.)
8. INPUT PARAMETER ENTER # OF SAMPLES ?_	8. The number of samples = 3, touch RETURN(EXEC).
9. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	9. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 8. NOTE: The parameter is displayed for verification.

Example

Run the Kruskal-Wallis Test on the following samples of data: $n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS
10. INPUT SAMPLE SIZE FOR SAMPLE 1 ENTER SAMPLE SIZE ?_	10. Sample 1 = 4, touch RETURN (EXEC).
11. INPUT SAMPLE SIZE FOR SAMPLE 1 SAMPLE SIZE OK (Y OR N) ?_	11. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 10. NOTE: The sample size is displayed for verification.
12. DATA INPUT FOR SAMPLE 1, ITEM #1 ENTER DATA VALUE ?_	12. Sample 1, item 1 = 98, touch RETURN(EXEC).
13. DATA INPUT FOR SAMPLE 1 ITEM #2 ENTER DATA VALUE ?_	13. Sample 1, item 2 = 80, touch RETURN(EXEC).

Enter all items in Sample 1 of example.

DISPLAYS	INSTRUCTIONS
14. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	14. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 10. If 'N', go to Section IV.

Example

Run the Kruskal-Wallis Test on the following samples of data: $n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS
	NOTE: The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC). Follow steps 10-14 to enter all samples. For System A only: The program is written to handle multi-volume files of data. The program contains a constant value that dictates the number of data records which can be stored per tape cassette. Once this number of records has been written, the volume is closed, and the following example instructions are displayed, after data cassette 1 has been rewound. a. REMOVE AND LABEL VOL 1 OF FILE NPS1F200 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_ b. MOUNT SCRATCH VOL TO BECOME VOL 2 OF FILE NPS1F200 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_
15. REMOVE AND LABEL VOL 1 OF FILE NPS1F200 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	15. After labeling the cassette, touch RETURN(EXEC). (For the System S, the file name is NSS1F200.)
16. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	16. Enter 'Y' or 'N' and touch RETURN(EXEC).

Example

Run the Kruskal-Wallis Test on the following samples of data: $n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS
	If 'Y', go to the next step. If 'N', go to step 20.
17. ENTER OUTPUT DEVICE TYPE SYMBOL ?_ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	17. Enter an output device symbol and touch RETURN(EXEC).
18. MOUNT VOL 1 OF FILE NPS1F200 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	18. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the program name is NSS1F200.) NOTE: If Volume 1 already is in Unit 1 from the corrections routine, ignore this step which is repeated for all volumes in a multi-volume System A.
19a. SETTING UP WORK AREAS	19a. The system now is setting up work areas.
b. SORTING DATA	b. The system now is sorting data.
c. SETTING UP AVERAGE RANKS	c. The system now is setting up average ranks.
d. ALIGNING AVERAGE RANKS	d. The system now is aligning average ranks.
e. SUM OF SAMPLE RANKS	e. The system now is calculating the sum of the sample ranks.
f. EXECUTING PROGRAM	f. The system now is executing the Kruskal-Wallis One-Way Analysis of Variance By Ranks Test.

Example

Run the Kruskal-Wallis Test on the following samples of data: $n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS
20. STOP END OF PROGRAM :_	20. The test results are displayed for verification.
	21. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

DISPLAYS	INSTRUCTIONS
A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 17.
B. MOUNT VOL 1 OF FILE NPS1F200 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F200. Go to Section II.)
C. ENTER # OF TAPE DRIVES (1 OR 2) ?_	C. Enter 1 or 2 and touch RETURN (EXEC). If 1, go to Section II. If 2, go to Section III.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. SAMPLE IN ERROR (0 IF END) ?_	A. Enter the sample in error or 0 and touch RETURN(EXEC). If a sample number is entered, go to the next step. If '0', go to step 16.

Example

Run the Kruskal-Wallis Test on the following samples of data:
$n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS
	NOTE: If the data file contains more than one volume, the program determines the location of the record and displays the appropriate volume to mount; see step B. For the System S, ignore step B.
B. MOUNT VOL 2 OF FILE NPS1F200 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section II. If 'N', go to Section IV.
	NOTE: The input data is displayed for verification. Follow steps A-C for all corrections. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION III
TWO TAPE DRIVE CORRECTION

A. SAMPLE # IN ERROR (0 IF END) ?_	A. Enter the sample in error or 0 and touch RETURN(EXEC). If a sample number is entered, go to the next step. If '0', go to step 16.

Example

Run the Kruskal-Wallis Test on the following samples of data: $n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS
	NOTE: Sample numbers must be entered sequentially.
B. MOUNT VOL 2 OF FILE NPS1F200 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC).
	NOTE: This prompt only appears when the sample selected is not located in Volume 1.
C. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F200 - UNIT 2 KEY RETURN(EXEC) TO RESUME ?_	C. Mount a scratch cassette in Unit 2 and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section III. If 'N', go to Section IV.
	NOTE: Follow steps A-D for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

Example

Run the Kruskal-Wallis Test on the following samples of data: $n_1 = 4$, $n_2 = 4$, $n_3 = 4$.

1	98	80	84	73
2	94	80	126	59
3	113	94	162	145

DISPLAYS	INSTRUCTIONS

SECTION IV
DATA CORRECTION

DISPLAYS	INSTRUCTIONS
A. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the item in error and touch RETURN (EXEC). NOTE: If the sample selected contains only one item, ignore this step.
B. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-4 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC). NOTE: Follow steps A and B for all samples. If proceeding from step 14, that step reappears; follow the appropriate operating instructions. If proceeding from either step C of Section II or step D of Section III, one of those steps reappears; follow the appropriate operating instructions.

```
THE KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE BY RANKS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF SAMPLES =  3


DATA INPUT:

SAMPLE 1 , SIZE =  4
 98            80            84            73

SAMPLE 2 , SIZE =  4
 94            80            126           59

SAMPLE 3 , SIZE =  4
 113           94            162           145




THE KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE BY RANKS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF SAMPLES =  3


RANK VALUES:

SAMPLE 1 , SIZE =  4
 8             3.5           5             2

SAMPLE 2 , SIZE =  4
 6.5           3.5           10            1

SAMPLE 3 , SIZE =  4
 9             6.5           12            11


THE KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE BY RANKS TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


# OF SAMPLES =  3


SAMPLE RANK TOTALS R(J):

 18.5          21            38.5

SUM(R(J)^2/N(J)) =  566.375
 CORRECTION TERM =  12



   H =  4.56730769231
H(C) =  4.599471830988
D.F. =  2



END OF PROGRAM
```

CHAPTER XXIV THE CONTINGENCY COEFFICIENT: C

PROGRAM ABSTRACT

The program computes the measure of the extent of association between the attributes. It is extremely useful for categorical data.

PROGRAM DESCRIPTION

Frequently, it is desirable to determine if two sets of scores are related and if so, to what degree. It may also be relevant to determine the significance of this association. In parametric statistics, the test usually employed to determine correlation is the Pearson product-moment correlation coefficient r. To determine r, we require that the scores are measured in at least an equal-interval scale. If we also desire the significance level, then we must assume that the scores are from a bivariate normal distribution. When these assumptions cannot be met, we now can apply nonparametric methods which assume nothing about the shape of the sample's population. A nonparametric test which can be used is the Contingency Coefficient: C.

The value C is the measure of the extent of association between two attributes. It is especially useful for categorical (nominal) data. These frequency values are placed in a contingency table and the computed value is the same regardless of how the categories are arranged in columns and rows. There are k columns and r rows, and the two categories are $A_1 \ldots A_k$ and $B_1 \ldots B_r$.

	A_1	A_2	A_3	. . .	A_k	Total
B_1	(A_1B_1)	(A_2B_1)	(A_3B_1)	. . .	(A_kB_1)	
B_2	(A_1B_2)	(A_2B_2)	(A_3B_2)	. . .	(A_kB_2)	
⋮	⋮	⋮	⋮	. . .	⋮	
B_r	(A_1B_r)	(A_2B_r)	(A_3B_r)	. . .	(A_kB_r)	
Total						N

We then compute the expected frequencies that would occur if there were no association between the two variables. The larger the values between the observed and expected frequencies, the larger is the degree of association between the two variables, and the larger is C. The following formulas are used:

$$C = \sqrt{\frac{X^2}{N + X^2}}$$

where:

$$X^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

For critical values, we use the X^2 value used in the formula for C and use a Chi-Square table with (k-1)(r-1) degrees of freedom.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statements 180 and 190 of the program. By changing Statements 180 and 190, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

After information is temporarily stored internally in the System 2200, it is stored permanently on a tape cassette. When the system is turned off, information stored in the system is lost, but information stored on the tape cassette remains intact.

The observations on the tape are arranged in groups called records. In this program, one row is a record. During entry, the record is written on the tape after the entire cell is entered and checked.

Because the tape has a fixed length, a maximum number of records can be written on it. Two lengths are available: 75 feet (Wang Part # 174-1250) and 150 feet (Wang Part # 174-1251). The program is designed for use of 150 foot tapes.

The length of a record depends on the number of columns. The maximum number of records on the tape cassette depends on the length of the record. If all the data cannot be stored on a single cassette, two or more cassettes are used. As the records are written, they are counted. When the maximum is reached, cassette changing messages are displayed (only one cassette for data is allowed in the System S).

As it is sold, the program contains the following maximum parameters:

System A: C = 75, 97 for the maximum number of records per cassette.

System S: C = 145, 47 for the maximum number of records per cassette.

Where C = number of columns.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of C:

   $2 * C \leq$ the number of variables available.

2. Select the appropriate value of C for your system from the following table:

CAPACITY	8K	12K
C for System A	75	255
C for System S	145	255

3. Look up the maximum number of records per cassette (D') in the following table:

	24	52	80	108	136	164	192	220	248	255
75 feet	146	72	47	35	27	22	19	16	14	12
150 feet	296	147	97	72	57	47	40	35	31	27

*if your max is not listed, refer to the next highest increment.

> NOTE:
>
> In the System S, the number of records used is not checked against the number allowed. Remember not to exceed the table value or an error results.

4. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR and RETURN(EXEC).

5. Key LOAD "NPS121AA" for the System A or LOAD "NSS121AA" for the System S, and touch RETURN(EXEC).

6. Key LIST 180, and touch RETURN(EXEC). The screen should display:

```
System A: 180 DIM X(75),R(75)
          190 SELECT #110A,#210B:D=97:H=32

System S: 180 DIM X(145),R(145):SELECT #110A
```

7. Rekey Statements 180 and 190 using the new maximum parameters:

```
System A: 180 DIM X(C),R(C)
          190 SELECT #110A,#210B:D=D':H=32

System S: 180 DIM X(C),R(C):SELECT #110A
```

   Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS121AA" for the System A, or "NSS121AA" for the System S, and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Compute the value of C for the following data:

k = 4

	20	37	13	1
r=3	12	76	93	13
	3	33	57	11

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS121AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). (For the System S, the program name is "NSS121AA".)
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Compute the value of C for the following data:

k = 4, r=3

20	37	13	1
12	76	93	13
3	33	57	11

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN(EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' or STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F210 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	7. Mount a scratch cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F210.)
8. INPUT PARAMETERS ENTER # OF ROWS ?_	8. The number of rows = 3, touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER # OF COLUMNS ?_	9. The number of columns = 4, touch RETURN(EXEC).
10. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 8.

Example

Compute the value of C for the following data:

k = 4

r=3				
	20	37	13	1
r=3	12	76	93	13
	3	33	57	11

DISPLAYS	INSTRUCTIONS
11. DATA INPUT FOR ROW #1, COLUMN 1 ENTER DATA VALUE ?_	11. Row 1, column 1 = 20, touch RETURN(EXEC).
12. DATA INPUT FOR ROW #1, COLUMN 2 ENTER DATA VALUE ?_	12. Row 1, column 2 = 37, touch RETURN(EXEC).

Enter all items in Row 1 of example.

DISPLAYS	INSTRUCTIONS
13. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section IV.

NOTE:

Follow steps 11-13 to enter all rows. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN (EXEC). For System A only: The program is written to handle multi-volume files of data. The program contains a constant value that dictates the number of data records which can be stored per tape cassette. Once this number of records has been written, the volume is closed, and the following example instructions are displayed, after data cassette 1 has been rewound. (Note continued)

Example

Compute the value of C for the following data:

k = 4, r=3

20	37	13	1
12	76	93	13
3	33	57	11

DISPLAYS	INSTRUCTIONS
	a. REMOVE AND LABEL VOL 1 OF FILE NPS1F210 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_ b. MOUNT SCRATCH VOL TO BECOME VOL 2 OF FILE NPS1F210 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F210 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC). (For the System S, the file name is NSS1F210.)
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?_ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	16. Enter an output device symbol and touch RETURN(EXEC).
17. MOUNT VOL 1 OF FILE NPS1F210 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F210.) NOTE: If Volume 1 already is in Unit 1 from the corrections routine, ignore this step.

Example

Compute the value of C for the following data:

k = 4

	20	37	13	1
r=3	12	76	93	13
	3	33	57	11

DISPLAYS	INSTRUCTIONS
18a. COMPUTE COLUMN TOTALS	18a. The system now is computing the column totals.
b. EXECUTING PROGRAM	b. The system now is executing the Contingency Coefficient Test.
19. STOP END OF PROGRAM :_	19. The test results are displayed for verification.
	20. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 16.
B. MOUNT VOL 1 OF FILE NPS1F210 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F210. Go to Section II.)
C. ENTER # OF TAPE DRIVES (1 OR 2) ?_	C. Enter 1 or 2 and touch RETURN (EXEC). If 1, go to Section II. If 2, go to Section III.

SECTION II
ONE TAPE DRIVE CORRECTION

A. ROW # IN ERROR (0 IF END) ?_	A. Enter the row in error or 0 and touch RETURN(EXEC).

Example

Compute the value of C for the following data:

k = 4

	20	37	13	1
r=3	12	76	93	13
	3	33	57	11

DISPLAYS	INSTRUCTIONS
	If a row number is entered, go to the next step. If '0', go to step 15.
	NOTE: If the data file contains more than one volume, the program determines the location of the record and displays the appropriate volume to mount. See step B. For the System S, ignore step B.
B. MOUNT VOL 2 OF FILE NPS1F210 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section II. If 'N', go to Section IV.
	NOTE: Follow steps A-C for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION III
TWO TAPE DRIVE CORRECTION

A. ROW # IN ERROR (0 IF END) ?_	A. Enter the row in error or 0 and touch RETURN(EXEC).

Example

Compute the value of C for the following data:

k = 4

r=3	20	37	13	1
	12	76	93	13
	3	33	57	11

DISPLAYS	INSTRUCTIONS
	If a row number is entered, go to the next step. If '0', go to step 15. NOTE: Row numbers must be entered sequentially.
B. MOUNT VOL 2 OF FILE NPS1F210 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). NOTE: This prompt only appears when the row selected is not located in Volume 1.
C. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F210 - UNIT 2 KEY RETURN(EXEC) TO RESUME ?_	C. Mount a scratch cassette in Unit 2 and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR ROW #1, ITEMS #1-4 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section III. If 'N', go to Section IV. NOTE: Follow steps A-D for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'y' and touch RETURN (EXEC).

Example

Compute the value of C for the following data:

k = 4

r=3

20	37	13	1
12	76	93	13
3	33	57	11

DISPLAYS	INSTRUCTIONS

SECTION IV
DATA CORRECTION

A. CORRECTION ROUTINE FOR
ROW #1, ITEMS #1-4
ENTER ITEM # OF BAD DATA
?_

A. Counting from left to right, enter the number of the item in error and touch RETURN(EXEC).

> NOTE:
>
> If the row selected contains only one item, ignore this step.

B. CORRECTION ROUTINE FOR
ROW #1, ITEMS #1-4
ENTER CORRECT DATA VALUE
?_

B. Enter the correct data value and touch RETURN(EXEC).

> NOTE:
>
> Follow steps A and B for all rows. If proceeding from step 13, that step reappears; follow the appropriate operating instructions. If proceeding from either step C of Section II or step D of Section III, one of those steps reappears; follow the appropriate operating instructions.

```
THE CONTINGENCY COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


   # OF ROWS =  3
# OF COLUMNS =  4


INPUT DATA:

ROW # 1
 20              37               13               1

ROW # 2
 12              76               93               13

ROW # 3
 3               33               57               11


THE CONTINGENCY COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


   # OF ROWS =  3
# OF COLUMNS =  4


      I      J          O(I, J)               E(I, J)                X(I, J)

      1      1          20. 0000          6. 734417344          26. 130795614
      1      2          37. 0000         28. 092140921           2. 824631756
      1      3          13. 0000         31. 363143631          10. 751634083
      1      4           1. 0000          4. 810298102           3. 018185427
      2      1          12. 0000         18. 401084010           2 226709931
      2      2          76. 0000         76. 758807588           0. 007501275
      2      3          93. 0000         85. 696476964           0. 622446226
      2      4          13. 0000         13. 143631436           0. 001569580
      3      1           3. 0000          9. 864498644           4. 776861282
      3      2          33. 0000         41. 149051490           1. 613817033
      3      3          57. 0000         45. 940379403           2. 662477091
      3      4          11. 0000          7. 046070460           2. 218762768


THE CONTINGENCY COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


   # OF ROWS =  3
# OF COLUMNS =  4


CHI-SQUARE =  56. 85539207056
      D. F.  =  6

         C =  . 36538839868


END OF PROGRAM
```

CHAPTER XXV THE SPEARMAN RANK CORRELATION COEFFICIENT: r_s

PROGRAM ABSTRACT

The program computes the statistic which is used to indicate if two samples are related and to what degree. It requires that both variables are measured in at least an ordinal scale.

PROGRAM DESCRIPTION

Frequently, it is desirable to determine if two sets of scores are related and if so, to what degree. It also may be relevant to determine the significance of this association. In parametric statistics, the test usually employed to determine correlation is the Pearson product-moment correlation coefficient r. To determine r, we require that the scores are measured in at least an equal-interval scale. If we also desire the significance level, then we must assume that the scores are from a bivariate normal distribution. When these assumptions cannot be met, we now can apply nonparametric methods which assume nothing about the shape of the sample's population. One such test is the Spearman Rank Correlation Coefficient: r_s.

The Spearman coefficient is probably the best known today since it was the earliest to be developed. It requires that both variables are measured in at least an ordinal scale so that the subjects can then be ranked in two ordered series. Then, by taking the difference between these two series, we compute the correlation:

$$r_s = 1 - \frac{6 \sum_{i=1}^{N} d_i^2}{N^3 - N}$$

where N is the number of sample values and d_i is the difference between the series at the ith spot in the series.

If the proportion of ties in the samples is small, it has a negligible effect on the coefficient value. However, with a high proportion, a correction factor is necessary. In the case of ties, the program breaks ties by allocating average ranks. The coefficient values are computed by the program with and without the correction term. The formula with a correction term is:

$$r_s = \frac{\Sigma X^2 + \Sigma Y^2 - \Sigma d^2}{2\sqrt{\Sigma X^2 \, \Sigma Y^2}}$$

where $\Sigma X^2 = \frac{N^3 - N}{12} - \Sigma T_x$

$$\Sigma Y^2 = \frac{N^3 - N}{12} - \Sigma T_y$$

$$T = \frac{t^3 - t}{12} \quad \text{Correction term}$$

where t is the number of ties values at a given rank.

If N is less than 10, we use the table generated for the Spearman Test to determine critical values. If N is greater than or equal to 10, we use a Student's t with N-2 degrees of freedom and then the t-tables.

$$t = r_s \sqrt{\frac{N - 2}{1 - r_s^2}}$$

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

N = 48, where N = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of N:

   $5 * N \leq$ the number of variables available.

2. Select the appropriate value of N for your system from the following table:

CAPACITY	8K	12K	16K	20K
N for System A	48	151	253	255

3. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND.

4. Key LOAD "NPS122AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).

   The screen should display:

```
170 DIM X(48),Y(48),S(48),A(48),P(48):
    SELECT #110A:D=32
```

6. Rekey statement, using the new maximum parameters:

```
170 DIM X(N),Y(N),S(N),A(N),P(N):
    SELECT #110A:D=32
```

7. Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS122AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

To what degree do the following samples X and Y correspond?

X	0	0	9	9	27	36	45	54	63	72	72	101
Y	41	45	38	36	64	87	85	55	61	91	53	80

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN (EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS122AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).
5. TEST INFORMATION INFORMATION OK (Y OR N) ?-	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2.

Example

To what degree do the following samples X and Y correspond?

X	0	0	9	9	27	36	45	54	63	72	72	101
Y	41	45	38	36	64	87	85	55	61	91	53	80

DISPLAYS	INSTRUCTIONS
	NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F220 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETER ENTER SAMPLE SIZE ?_	9. The sample size = 12, touch RETURN(EXEC).
10. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9. NOTE: The parameter is displayed for verification.
11. DATA INPUT FOR SAMPLE X, ITEM #1 ENTER DATA VALUE ?_	11. Sample X, item 1=0, touch RETURN(EXEC).

Example

To what degree do the following samples X and Y correspond?

X	0	0	9	9	27	36	45	54	63	72	72	101
Y	41	45	38	36	64	87	85	55	61	91	53	80

DISPLAYS	INSTRUCTIONS
12. DATA INPUT FOR SAMPLE X, ITEM #2 ENTER DATA VALUE ?_	12. Sample X, item 2=0, touch RETURN(EXEC).

Enter all items in Sample X of example.

DISPLAYS	INSTRUCTIONS
13. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.

NOTE:

The input data for Sample X is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN (EXEC).

DISPLAYS	INSTRUCTIONS
14. DATA INPUT FOR SAMPLE Y, ITEM #1 ENTER DATA VALUE ?_	14. Sample Y, item 1=41, touch RETURN(EXEC).
15. DATA INPUT FOR SAMPLE Y, ITEM #2 ENTER DATA VALUE ?_	15. Sample Y, item 2=45, touch RETURN(EXEC).

Enter all items of Sample Y in example.

DISPLAYS	INSTRUCTIONS
16. CORRECTION ROUTINE FOR SAMPLE Y, ITEMS #1-12 IS DATA OK (Y OR N) ?_	16. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.

Example

To what degree do the following samples X and Y correspond?

X	0	0	9	9	27	36	45	54	63	72	72	101
Y	41	45	38	36	64	87	85	55	61	91	53	80

DISPLAYS	INSTRUCTIONS
	NOTE: The input data for Sample Y is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
17. REMOVE AND LABEL VOL 1 OF FILE NPS1F220 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 18.
18. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	18. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 22.
19. ENTER OUTPUT DEVICE TYPE SYMBOL. ?-- FOR CRT ONLY, KEY RETURN(EXEC); FOR HIGH SPEED, KEY 'HS'; FOR THERMAL, KEY 'TH'; FOR PLOTTER(2202), KEY 'P'; FOR TYPEWRITER, KEY 'TY'	19. Enter an output device symbol and touch RETURN(EXEC).
20. MOUNT VOL 1 OF FILE NPS1F220 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	20. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 21b.
21a. READING DATA RECORD	21a. The system now is reading the data record.

Example

To what degree do the following samples X and Y correspond?

X	0	0	9	9	27	36	45	54	63	72	72	101
Y	41	45	38	36	64	87	85	55	61	91	53	80

DISPLAYS	INSTRUCTIONS
b. CREATING WORK AREAS	b. The system now is creating work areas.
c. SORTING DATA	c. The system now is sorting the data. (This message is repeated for each sample.)
d. SETTING UP AVERAGE RANKS	d. The system now is setting up average ranks. (This message is repeated for each sample.)
e. ALIGNING AVERAGE RANKS	e. The system now is aligning average ranks. (This message is repeated for each sample.)
f. EXECUTING PROGRAM	f. The system now is executing the Spearman Rank Correlation Coefficient Test.
22. STOP END OF PROGRAM :_	22. The test results are displayed for verification.
	23. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 19.

SECTION II
ONE TAPE DRIVE CORRECTION

A. MOUNT VOL 1 OF FILE NPS1F220 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).

Example

To what degree do the following samples X and Y correspond?

X	0	0	9	9	27	36	45	54	63	72	72	101
Y	41	45	38	36	64	87	85	55	61	91	53	80

DISPLAYS	INSTRUCTIONS
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F220 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample X and Sample Y are displayed for verification in steps C and D, respectively. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR SAMPLE Y, ITEMS #1-12 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 17. If 'N', go to Section III.

SECTION III
DATA CORRECTION

A. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the item in error and touch RETURN(EXEC). NOTE: If there is only one item remaining in a sample, ignore step A.

Example

To what degree do the following samples X and Y correspond?

X	0	0	9	9	27	36	45	54	63	72	72	101
Y	41	45	38	36	64	87	85	55	61	91	53	80

DISPLAYS	INSTRUCTIONS
B. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data values and touch RETURN(EXEC).

NOTE:

If proceeding from either step 13 or step 16, one of those steps reappears; follow the appropriate operating instructions. If proceeding from either step C or step D of Section II, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE SPEARMAN RANK CORRELATION COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

SAMPLE SIZE =  12

INPUT DATA/RANK VALUES:

INPUT DATA X
 0              0              9              9              27
 36             45             54             63             72
 72             101

RANK DATA X:
 1.5            1.5            3.5            3.5            5
 6              7              8              9              10.5
 10.5           12

INPUT DATA Y
 41             45             38             36             64
 87             85             55             61             91
 53             80

RANK DATA Y:
 3              4              2              1              8
 11             10             6              7              12
 5              9

RANK DIFFERENCES:
-1.5           -2.5            1.5            2.5           -3
-5             -3              2              2             -1.5
 5.5            3
```

```
THE SPEARMAN RANK CORRELATION COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SAMPLE SIZE =  12


                VALUE               WITH CT          CT
SUM OF X^2 =  143                    141.5            1.5
SUM OF Y^2 =  143                    143              0
SUM OF D^2 =  109.5

R(S) =   .617132867133             .6151227852535


   T =   2.467163559942
D.F. =   10


END OF PROGRAM
```

CHAPTER XXVI THE KENDALL RANK CORRELATION COEFFICIENT

PROGRAM ABSTRACT

The program gives a measure of the degree of association between two variables X and Y. It uses the rank values for each sample as test data. It is sort of a coefficient of disarray.

PROGRAM DESCRIPTION

Frequently, it is desirable to determine if two sets of scores are related and if so, to what degree. It may also be relevant to determine the significance of this association. In parametric statistics, the test usually employed to determine correlation is the Pearson product-moment correlation coefficient r. To determine r, we require that the scores are measured in at least an equal-interval scale. If we also desire the significance level, then we must assume that the scores are from a bivariate normal distribution. When these assumptions cannot be met, we now can apply nonparametric methods which assume nothing about the shape of the sample's population. A nonparametric test which can be used is the Kendall Rank Correlation Coefficient: τ.

The Kendall Test can be used for categorical data. In other words, both the X and Y variables must be from an ordinal scale. Then each data subject can be assigned a rank on both X and Y. The value will then give a measure of the degree of association between the two sets of ranks. Given N objects to rank, the data would be of a form:

	1	2	3	4		N
X	x_1	x_2	x_3	x_4	. . .	x_N
Y	y_1	y_2	y_3	y_4	. . .	y_N

Then each data value would be replaced by a rank value within each sample.

	1	2	3	4		N
X	xr_1	xr_2	xr_3	xr_4	. . .	xr_N
Y	yr_1	yr_2	yr_3	yr_r	. . .	yr_N

Let us arrange the rank values in natural order for X, moving the Y ranks as a matched pair of the X rank.

	1	2	3	4		N
X	r_1	r_2	r_3	r_4	. . .	r_N
Y	r'_1	r'_2	r'_3	r'_4	. . .	r'_N

Now let us determine the number of pairs of ranks in Y in natural order with respect to each other. In other words, given the Y rank pair example (r_i, r_j), we assign the following values for the three situations: For $i \neq j$,

If $r'_i < r'_j$, $S_{ij} = +1$

If $r'_i = r'_j$, $S_{ij} = 0$

If $r'_i > r'_j$, $S_{ij} = -1$

This is done for all values of $i = 1, \ldots, N$ and $j = 2, \ldots, N$. The degree of association is then computed from the ratio of the total of +1's and -1's to the possible maximum total.

$$\tau = \frac{\text{Actual Total}}{\text{Maximum Possible}} = \frac{\Sigma S_{ij}}{\binom{N}{2}}$$

The ratio value is a sort of coefficient of disarray. In the case of tied observations, the average ranks are handed out. Thus, we have two formulas for computation:

If there are no tied observations, $S = \Sigma S_{ij}$

$$\tau = \frac{S}{\frac{N(N-1)}{2}} \qquad \text{where} \quad \binom{N}{2} = \frac{N(N-1)}{2}$$

If there are tied values,

$$\tau_{ct} = \frac{S}{\sqrt{N(N-1)/2 - T_x}\ \sqrt{N(N-1)/2 - T_y}}$$

where $T = \Sigma t(t-1)/2$
t = No. tied observations in each group of ties.

For critical values, we use the value N to choose the approach.

If $N \leq 10$, we use a table generated to give the values.

If $N > 10$, we use a normal approximation and the normal tables, N(0,1).

$$z = \frac{\tau}{\sqrt{\frac{2(2N+5)}{9N(N-1)}}}$$

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

N = 49, where N = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of N:

   $5 * N \leq$ the number of variables available.

2. Select the appropriate value of N for your system from the following table:

CAPACITY	8K	12K	16K	20K
N for System A	49	151	253	255

3. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND.

4. Key LOAD "NPS123AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).

   The screen should display:

```
170  DIM X(49),Y(49),S(49),A(49),P(49):
     SELECT #110A:D=32
```

6. Rekey statement, using the new maximum parameters:

```
170  DIM X(N),Y(N),S(N),A(N),P(N):
     SELECT #110A:D=32
```

7. Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS123AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Compute the value τ for the following data: N = 12.

X	40	44	37	35	63	84
	82	54	60	90	52	79
Y	1	1	3	3	6	8
	10	12	14	16	16	21

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B.
	A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI.
	B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS123AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Compute the value τ for the following data: N = 12.

X	40	44	37	35	63	84
	82	54	60	90	52	79
Y	1	1	3	3	6	8
	10	12	14	16	16	21

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F230 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER SAMPLE SIZE ?_	9. Sample size = 12, touch RETURN (EXEC).
10. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.

Example

Compute the value τ for the following data: N = 12.

X	40	44	37	35	63	84
	82	54	60	90	52	79
Y	1	1	3	3	6	8
	10	12	14	16	16	21

DISPLAYS	INSTRUCTIONS
11. DATA INPUT FOR SAMPLE X, ITEM #1 ENTER DATA VALUE ?_	11. Sample X, item 1=40, touch RETURN(EXEC).
12. DATA INPUT FOR SAMPLE X, ITEM #2 ENTER DATA VALUE ?_	12. Sample X, item 2=44, touch RETURN(EXEC).

Enter all items in Sample X of example

DISPLAYS	INSTRUCTIONS
13. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample X is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
14. DATA INPUT FOR SAMPLE Y, ITEM #1 ENTER DATA VALUE ?_	14. Sample Y, item 1 = 1, touch RETURN(EXEC).
15. DATA INPUT FOR SAMPLE Y, ITEM #2 ENTER DATA VALUE ?_	15. Sample Y, item 2 = 1, touch RETURN(EXEC).

Enter all items in Sample Y of example.

Example

Compute the value τ for the following data: N = 12.

X	40	44	37	35	63	84
	82	54	60	90	52	79
Y	1	1	3	3	6	8
	10	12	14	16	16	21

DISPLAYS	INSTRUCTIONS
16. CORRECTION ROUTINE FOR SAMPLE Y, ITEMS #1-12 IS DATA OK (Y OR N) ?_	16. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample Y is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
17. REMOVE AND LABEL VOL 1 OF FILE NPS1F230 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	15. After labeling the cassette, touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 18.
18. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	18. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 22.
19. ENTER OUTPUT DEVICE TYPE SYMBOL ?_ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	19. Enter an output device symbol and touch RETURN(EXEC).

Example

Compute the value τ for the following data: N = 12.

X	40	44	37	35	63	84
	82	54	60	90	52	79
Y	1	1	3	3	6	8
	10	12	14	16	16	21

DISPLAYS	INSTRUCTIONS
20. MOUNT VOL 1 OF FILE NPS1F230 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	20. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 21b.
21a. READING DATA RECORD	21a. The system now is reading the data record.
b. CREATING WORK AREAS	b. The system now is creating work areas for both samples.
c. SORTING DATA	c. The system now is sorting data from sample X. (This message reappears for Sample Y.)
d. SETTING UP AVERAGE RANKS	d. The system now is setting up average ranks for Sample X. (This message reappears for Sample Y.)
e. ALIGNING AVERAGE RANKS	e. The system is aligning average ranks for Sample X. (This message reappears for Sample Y.)
f. SORTING X & Y DATA SAMPLE	f. The system now is sorting the X and Y data samples.
g. EXECUTING PROGRAM	g. The system now is executing the Kendall Rank Correlation Coefficient Test.
22. STOP END OF PROGRAM :_	22. The test results are displayed for verification.
	23. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

Example

Compute the value τ for the following data: N = 12.

X	40	44	37	35	63	84
	82	54	60	90	52	79
Y	1	1	3	3	6	8
	10	12	14	16	16	21

DISPLAYS	INSTRUCTIONS

SECTION I
DATA FROM STORAGE

DISPLAYS	INSTRUCTIONS
A. INPUT INFORMATION DO YOU WISH TO CORRECT DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 19.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. MOUNT VOL 1 OF FILE NPS1F230 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F230 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample X and Sample Y are displayed for verification in Steps C and D, respectively. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

Example

Compute the value τ for the following data: N = 12.

X	40	44	37	35	63	84
	82	54	60	90	52	79
Y	1	1	3	3	6	8
	10	12	14	16	16	21

DISPLAYS	INSTRUCTIONS
D. CORRECTION ROUTINE FOR SAMPLE Y, ITEMS #1-12 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 17. If 'N', go to Section III.

SECTION III
DATA CORRECTION

A. CORRECTION ROUTINE FOR
SAMPLE X, ITEMS #1-12
ENTER ITEM # OF BAD DATA
?_

A. Counting from left to right, enter the number of the item in error and touch RETURN (EXEC).

> NOTE:
>
> If only one item remains in a sample, go to step B.

B. CORRECTION ROUTINE FOR
SAMPLE X, ITEMS #1-12
ENTER CORRECT DATA VALUE
?_

B. Enter the correct value and touch RETURN(EXEC).

> NOTE:
>
> If proceeding from either step 13 or step 16, one of those steps reappears; follow the appropriate operating instructions. If proceeding from either step C or step D of Section II, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE KENDALL RANK CORRELATION COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


SAMPLE SIZE =  12

INPUT DATA X:
 40             44             37             35             63
 84             82             54             60             90
 52             79

RANK DATA X:
 3              4              2              1              8
 11             10             6              7              12
 5              9


INPUT DATA Y:
 1              1              3              3              6
 8              10             12             14             16
 16             21

RANK DATA Y:
 1.5            1.5            3.5            3.5            5
 6              7              8              9              10.5
 10.5           12


ORDERED RANK DATA Y:
 3.5            3.5            1.5            1.5            10.5
 8              9              5              12             7
 6              10.5


THE KENDALL RANK CORRELATION COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B.   WRIGHT
DATE: 4/2/75


SAMPLE SIZE =  12


CT(X) =  0       CT(Y) =  3
    S =  25

    TAU =  .3787878787879
TAU(CT) =  .3877017543341

Z =  1.754656015838


END OF PROGRAM
```

CHAPTER XXVII THE KENDALL PARTIAL RANK CORRELATION COEFFICIENT

PROGRAM ABSTRACT

The program computes the measure of the degree of association between two variables X and Y, keeping the third variable Z constant to eliminate its effect on the other two. The data is assumed to be measured on at least an ordinal scale.

PROGRAM DESCRIPTION

Frequently, it is desirable to determine if two sets of scores are related and if so, to what degree. It may also be relevant to determine the significance of this association. In parametric statistics, the test usually employed to determine correlation is the Pearson product-moment correlation coefficient r. To determine r, we require that the scores are measured in at least an equal-interval scale. If we also desire the significance level, then we must assume that the scores are from a bivariate normal distribution. When these assumptions cannot be met, we now can apply nonparametric methods which assume nothing about the shape of the sample's population. A nonparametric test which can be used is the Kendall Partial Rank Correlation Coefficient: $\tau_{xy \cdot z}$

When testing for correlation between two variables, it is always possible that the results are due to the relations between the two variables and a third unknown. Thus, the Kendall Partial Test eliminates the third variable Z by keeping it constant and looks for the correlation between the X and Y variables. The only assumption necessary is that the data can be measured in at least an ordinal scale:

	1	2	3		N
X	x_1	x_2	x_3	. . .	x_N
Y	y_1	y_2	y_3	. . .	y_N
Z	z_1	z_2	z_3	. . .	z_N

Each data value in the X variable set is replaced by its corresponding rank value. The same is done for the Y and Z variable sets.

	1	2	3		N
X	xr_1	xr_2	xr_3	. . .	xr_N
Y	yr_1	yr_2	yr_3	. . .	yr_N
Z	zr_1	zr_2	zr_3	. . .	zr_N

With the original data values replaced by rank values, place the Z variable set in natural order moving the corresponding X and Y variable values into the same position as if the three values were a matched triplet.

	1	2	3		N
Z	r_1	r_2	r_3	. . .	r_N
X	Xr'_1	Xr'_2	Xr'_3	. . .	Xr'_N
Y	Yr'_1	Yr'_2	Yr'_3	. . .	Yr'_N

Let us look at all the possible rank pairs in Z, X, and Y. Assume the pairs are of the form (r_i, r_j), where $i < j$ for $i=1, \ldots, N$ and $j=2, \ldots, N$, then

if $r_i < r_j$, assign the pair a + sign.

if $r_i = r_j$, assign the pair a + sign.

if $r_i > r_j$, assign the pair a - sign.

Thus every pair will have a sign assigned to it.

PAIR	(1,2)	(1,3)	(1,4)		(N-1, N)
Z	+	+	+	. . .	+
X	+/-	+/-	+/-	. . .	+/-
Y	+/-	+/-	+/-	. . .	+/-

We summarize our findings in the following (2 x 2) table.

	Y PAIR SIGN = Z PAIR SIGN	Y PAIR SIGN ≠ Z PAIR SIGN	
X PAIR SIGN =Z PAIR SIGN	A	B	A + B
X PAIR SIGN ≠Z PAIR SIGN	C	D	C + D
	A + C	B + D	$\binom{N}{2}$

For example, if we look at pair (a,b), we have three signs under it. Say, both X and Y have + signs; then we would assign the pair to cell A since both pairs agree with Z. We then compute the coefficient using the following formula:

$$\tau_{xy.z} = \frac{AD - BC}{\sqrt{(A+B)\ (C+D)\ (A+C)\ (B+D)}}$$

If we desired to find the correlation between each pair of the three variables, keeping the third constant, we could use the results from Kendall's Rank Correlation Coefficient procedure. Then the following formula can be used:

$$\tau_{xy.z} = \frac{\tau_{xy} - \tau_{zy}\ \tau_{xz}}{\sqrt{(1 - \tau_{zy}^{2})\ (1 - \tau_{zx}^{2})}}$$

However, for this particular program, we use the first formula.

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

Because of the nature of the problem, only one data record is written. During entry, the record is written on the tape after the entire cell is entered and checked.

As it is sold, the program contains the following maximum parameters:

N = 33, where N = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of N:

   $6 * N \leq$ the number of variables available.

2. Select the appropriate value of N for your system from the following table:

CAPACITY	8K	12K	16K	20K
N for System A	33	118	204	255

3. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND. Key CLEAR and touch RETURN(EXEC).

4. Key LOAD "NPS124AA", and touch RETURN(EXEC).

5. Key LIST 170, and touch RETURN(EXEC).

   The screen should display:

```
170 DIM X(33),Y(33),Z(33),S(33),A(33),P(33):
    SELECT #110A:D=32
```

6. Rekey statement, using the new maximum parameters:

```
170 DIM X(N),Y(N),Z(N),S(N),A(N),P(N):
    SELECT #110A:D=32
```

7. Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS124AA", and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN (EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS124AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC).
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. INPUT INFORMATION STORE INPUT DATA ON TAPE CASSETTE (Y OR N) ?_	7. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
8. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F240 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Mount a scratch cassette and touch RETURN(EXEC).
9. INPUT PARAMETER ENTER SAMPLE SIZE ?_	9. Sample size = 12, touch RETURN(EXEC).

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
10. INPUT PARAMETER IS PARAMETER OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 9.
11. DATA INPUT FOR SAMPLE X, ITEM #1 ENTER DATA VALUE ?_	11. Sample X, item 1 = 35, touch RETURN(EXEC).
12. DATA INPUT FOR SAMPLE X, ITEM #2 ENTER DATA VALUE ?_	12. Sample X, item 2 = 19, touch RETURN(EXEC).

Enter all items in Sample X of example.

DISPLAYS	INSTRUCTIONS
13. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample X is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
14. DATA INPUT FOR SAMPLE Y ITEM #1 ENTER DATA VALUE ?_	14. Sample Y, item 1 = 50, touch RETURN(EXEC).

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
15. DATA INPUT FOR SAMPLE Y, ITEM #2 ENTER DATA VALUE ?_	15. Sample Y, item 2 = 30, touch RETURN(EXEC).

Enter all items in Sample Y of example.

DISPLAYS	INSTRUCTIONS
16. CORRECTION ROUTINE FOR SAMPLE Y, ITEMS #1-12 IS DATA OK (Y OR N) ?_	16. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III. NOTE: The input data for Sample Y is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
17. DATA INPUT FOR SAMPLE Z, ITEM #1 ENTER DATA VALUE ?_	17. Sample Z, item 1 = 141, touch RETURN(EXEC).
18. DATA INPUT FOR SAMPLE Z, ITEM #2 ENTER DATA VALUE ?_	18. Sample Z, item 2 = 105, touch RETURN(EXEC).

Enter all items in Sample Z of example.

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
19. CORRECTION ROUTINE FOR SAMPLE Z, ITEMS #1-12 IS DATA OK (Y OR N) ?_	19. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.
	NOTE: The input data for Sample Z is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
20. REMOVE AND LABEL VOL 1 OF FILE NPS1F240 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	20. After labeling the cassette, touch RETURN(EXEC).
	NOTE: If step 7 was answered negatively, ignore this step and go to step 21.
21. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	21. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 25.
22. ENTER OUTPUT DEVICE TYPE SYMBOL ?_	22. Enter an output device symbol and touch RETURN(EXEC).

```
FOR CRT ONLY,        KEY RETURN(EXEC)
FOR HIGH SPEED,      KEY 'HS'
FOR THERMAL,         KEY 'TH'
FOR PLOTTER(2202),   KEY 'P'
FOR TYPEWRITER,      KEY 'TY'
```

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
23. MOUNT VOL 1 OF FILE NPS1F240 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	23. Mount the indicated cassette and touch RETURN(EXEC). NOTE: If step 7 was answered negatively, ignore this step and go to step 24b.
24a. READING DATA RECORDS	24a. The system now is reading the data records.
b. CREATING WORK AREAS	b. The system now is creating the work areas. (This step is repeated for Samples Y and Z.)
c. SORTING DATA	c. The system now is sorting the data in Sample X. (This step is repeated for Samples Y and Z.)
d. SETTING UP AVERAGE RANKS	d. The system now is setting up average ranks. (This step is repeated for Samples Y and Z.)
e. ALIGNING AVERAGE RANKS	e. The system now is aligning average ranks. (This step is repeated for Samples Y and Z.)
f. SORTING X,Y, & Z DATA SAMPLES	f. The system now is sorting the X, Y and Z data samples.
g. EXECUTING PROGRAM	g. The system now is executing the Kendall Partial Ranks Correlation Coefficient Test.
25. STOP END OF PROGRAM :_	25. The test results are displayed for verification.

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
	26. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

SECTION I
DATA FROM STORAGE

A. INPUT INFORMATION DO YOU WISH TO CORRECT DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to Section II. If 'N', go to step 22.

SECTION II
ONE TAPE DRIVE CORRECTION

A. MOUNT VOL 1 OF FILE NPS1F240 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	A. Mount the indicated cassette and touch RETURN(EXEC).
B. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F240 - UNIT I KEY RETURN(EXEC) TO RESUME ?_	B. Mount a scratch cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
	NOTE: The input data for Samples X, Y, and Z are displayed in steps C, D, and E, respectively. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR SAMPLE Y, ITEMS #1-12 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to Section III.
E. CORRECTION ROUTINE FOR SAMPLE Z, ITEMS #1-12 IS DATA OK (Y OR N) ?_	E. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step 20. If 'N', go to Section III.

SECTION III
DATA CORRECTION

A. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right, enter the number of the item in error and touch RETURN(EXEC). NOTE: If only one item remains in a sample, go to Step B.

Example

Compute $\tau_{xy.z}$ for the following samples: N = 12.

X	35	19	47	27	23	39
	43	31	3	7	15	11
Y	50	30	55	15	10	35
	40	45	0	20	25	5
Z	141	105	105	27	26	17
	15	13	8	8	5	5

DISPLAYS	INSTRUCTIONS
B. CORRECTION ROUTINE FOR SAMPLE X, ITEMS #1-12 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC).

NOTE:

Follow steps A and B for all corrections. If proceeding from step 13, step 16 or step 19, one of those steps reappears; follow the appropriate operating instructions. If proceeding from step C, step D or step E of Section II, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

THE KENDALL PARTIAL RANK CORRELATION COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B. WRIGHT
DATE: 4/2/75

SAMPLE SIZE = 12

INPUT DATA X:

35	19	47	27	23
39	43	31	3	7
15	11			

RANK DATA X:

9	5	12	7	6
10	11	8	1	2
4	3			

INPUT DATA Y:

50	30	55	15	10
35	40	45	0	20
25	5			

RANK DATA Y:

11	7	12	4	3
8	9	10	1	5
6	2			

INPUT DATA Z:

141	105	105	27	26
17	15	13	8	8
5	5			

RANK DATA Z:

12	10.5	10.5	9	8
7	6	5	3.5	3.5
1.5	1.5			

ORDERED RANK DATA X

4	3	1	2	8
11	10	6	7	12
5	9			

ORDERED RANK DATA Y

6	2	1	5	10
9	8	3	4	12
7	11			

```
THE KENDALL PARTIAL RANK CORRELATION COEFFICIENT TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75


SAMPLE SIZE =  12


2X2 FREQUENCY TABLE:
                     39                 6
                     5                  16

T =  .6210590034071


END OF PROGRAM
```

CHAPTER XXVIII THE KENDALL COEFFICIENT OF CONCORDANCE: W

PROGRAM ABSTRACT

The program computes a value that measures the degree of correlation between k samples of size N. The program uses the ranks of the data values for test values.

PROGRAM DESCRIPTION

Frequently, it is desirable to determine if two sets of scores are related and if so, to what degree. It may also be relevant to determine the significance of this association. In parametric statistics, the test usually employed to determine correlation is the Pearson product-moment correlation coefficient r. To determine r, we require that the scores are measured in at least an equal-interval scale. If we also desire the significance level, then we must assume that the scores are from a bivariate normal distribution. When these assumptions cannot be met, we now can apply nonparametric methods which assume nothing about the shape of the sample's population. A nonparametric test which may be used is the Kendall Coefficient of Concordance: W.

The value W is used as a measure of the correlation between k samples of rankings of N sample values. This is useful for studies of interjudge or intertest reliability and of clusters of variables. There are two avenues of approach presented in the text. One uses the Spearman Test and computes all the possible coefficient values and averages them.

$$r_{s(AV)} = \frac{kW-1}{k-1}$$

However, there are $\binom{k}{2}$ rank correlations and if k is not small, the computation is tedious. The other approach is to assume that there is no agreement between our k samples. Then we can project results with perfect agreement. Thus given the ranks of the data, the sum of the ranks in each column under perfect agreement would be a multiple of k (k,...,Nk). But if there is no agreement, then the sum of the ranks would all be approximately equal. Therefore, if we look at the degree of variance between the N rank sums, W is a function of that degree of variance.

The procedure is to sum the columns of a (k x N) table of ranks.

	1	2	3		N
1	r_{11}	r_{12}	r_{13}	. . .	r_{1N}
2	r_{21}	r_{22}	r_{23}	. . .	r_{2N}
	⋮	⋮	⋮	⋮ ⋮ ⋮	⋮
k	r_{k1}	r_{k2}	r_{k3}	. . .	r_{kN}
	R_1	R_2	R_3		R_N

Then, we compute W using the following formula:

$$W = \frac{S}{\frac{1}{12} k^2 (N^3 - N)}$$

where k = No. of samples.

N = Sample size.

$$S = \sum_{j=1}^{N} \left(R_j - \frac{\Sigma R_j}{N} \right)^2$$

In the case of tied observations, we assign the average ranks and add a correction term to our formula which becomes:

$$W = \frac{S}{\frac{1}{12} k^2 (N^3 - N) - k \, \Sigma T} \qquad \text{where } \Sigma T = \frac{\Sigma (t^3 - t)}{12}$$

where t = No. of samples tied in a group.

For critical values, we use two methods:

If $N \leq 7$, we use a table generated for the test.

If $N > 7$, we compute a χ^2 value and use the Chi-Square table with (N-1) degrees of freedom.

$$\chi^2 = k (N-1) W$$

PROGRAM RESTRICTIONS

The parameters are entered through the keyboard during program operation. The maximum parameters are defined in Statement 170 of the program. By changing Statement 170, new maximum parameters can be defined, but they must not exceed absolute maximum parameters which depend on the capacity of the machine.

After information is temporarily stored internally in the System 2200, it is stored permanently on a tape cassette. When the system is turned off, information stored in the system is lost, but information stored on the tape cassette remains intact.

The observations on the tape are arranged in groups called records. In this program, one sample is a record. During entry, the record is written on the tape after the entire cell is entered and checked.

Because the tape has a fixed length, a maximum number of records can be written on it. Two lengths are available: 75 feet (Wang Part # 174-1250) and 150 feet (Wang Part # 174-1251). The program is designed for use of 150 foot tapes.

The length of a record depends on the sample size. The maximum number of records on the tape cassette depends on the length of the record. If all the data cannot be stored on a single cassette, two or more cassettes are used. As the records are written, they are counted. When the maximum is reached, cassette changing messages are displayed (only one cassette for data is allowed in the System S).

As it is sold, the program contains the following maximum parameters:

System A: C = 22, 296 for the maximum number of records per cassette.

System S: C = 48, 147 for the maximum number of records per cassette.

Where C = sample size.

If the parameters for your data do not exceed the given maximum parameters, use the program as it is. For larger maximum parameters, alter the program as follows (more memory may be required):

1. The following calculation is used to determine the value of C:

   $5 * C \leq$ the number of variables available.

2. Select the appropriate value of C for your system from the following table:

CAPACITY	8K	12K	16K	20K
C for System A	22	124	226	255
C for System S	48	151	253	

3. Look up the maximum number of records per cassette (D') in the following table:

	24	52	80	108	136	164	192	220	248	255
75 feet	146	72	47	35	27	22	19	16	14	12
150 feet	296	147	97	72	57	47	40	35	31	27

*if your max is not listed, refer to the next highest increment.

> NOTE:
>
> In the System S, the number of records used is not checked against the number allowed. Remember not to exceed the table value or an error results.

4. Insert System Tape #2 into Unit 1 (on the Console), close the door, and press REWIND.

5. Key LOAD "NPS125AA" for the System A or LOAD "NSS125AA" for the System S, and touch RETURN(EXEC).

6. Key LIST 170, and touch RETURN(EXEC). The screen should display:

```
System A: 170 DIM X(22),S(22),A(22),P(22),R(22):
          SELECT #110A,#210B:D=296:H=32

System S: 170 DIM X(48),S(48),A(48),P(48),R(48):
          SELECT #110A:H=32
```

7. Rekey Statement 170, using the new maximum parameters:

```
System A: 170 DIM X(C),S(C),A(C),P(C),R(C):
          SELECT #110A,#210B:D=D':H=32

System S: 170 DIM X(C),S(C),A(C),P(C),R(C):
          SELECT #110A:H=32
```

   Touch RETURN(EXEC).

8. Remove System Tape #2 from Unit 1, insert a blank tape cassette, and press REWIND.

9. Key SAVE "NPS125AA" for the System A, or "NSS125AA" for the System S, and touch RETURN(EXEC).

10. Press REWIND and remove the new Program Tape Cassette.

To execute the program with your new parameters, do not use System Tape #2. Use the new Program Tape Cassette and use Alternate Step 1B of the operating instructions.

Example

Measure the correlation between the following samples:

N = 10   k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS
	1. To load the MENU 2 program, follow operating instructions A. To bypass the MENU 2 program, follow operating instructions B. A. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). Follow the operating instructions in Chapter XVI. B. Mount the Nonparametric System Tape #2 in logical Unit 1. Type CLEAR and touch RETURN(EXEC). Type LOAD "NPS125AA" and touch RETURN(EXEC). Touch RUN and RETURN(EXEC). (For the System S, the program name is "NSS125AA".)
2. TEST INFORMATION ENTER PROJECT NAME ?--------------------------------	2. Enter the project name and touch RETURN(EXEC). (Project name can be up to 32 characters in length.)
3. TEST INFORMATION ENTER USER'S NAME ?--------------------------------	3. Enter the user's name and touch RETURN(EXEC). (User's name can be up to 32 characters in length.)
4. TEST INFORMATION ENTER TODAY'S DATE AS MM/DD/YY ?--------	4. Enter the date and touch RETURN(EXEC).

Example

Measure the correlation between the following samples:

N = 10 k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS
5. TEST INFORMATION INFORMATION OK (Y OR N) ?_	5. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 2. NOTE: The test information is displayed for verification. The message RE-ENTER is displayed if an incorrect entry is made. To continue, enter the appropriate symbol and touch RETURN (EXEC). This note applies in all instances where a symbol or a numeric is entered.
6. INPUT INFORMATION IS INPUT FROM KEYBOARD 'K' OR STORAGE 'S' ?_	6. Enter 'K' or 'S' and touch RETURN(EXEC). If 'K', go to the next step. If 'S', go to Section I.
7. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F250 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	7. Mount a scratch cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F250.)
8. INPUT PARAMETERS ENTER # OF SAMPLES ?_	8. The number of samples = 3, touch RETURN(EXEC).
9. INPUT PARAMETERS ENTER SAMPLE SIZE ?_	9. The sample size = 10, touch RETURN(EXEC).
10. INPUT PARAMETERS ARE PARAMETERS OK (Y OR N) ?_	10. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 8.

Example

Measure the correlation between the following samples:

N = 10 k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS
11. DATA INPUT FOR SAMPLE 1, ITEM #1 ENTER DATA VALUE ?_	11. Sample 1, item 1 = 1, touch RETURN(EXEC).
12. DATA INPUT FOR SAMPLE 1, ITEM #2 ENTER DATA VALUE ?_	12. Sample 1, item 2 = 8, touch RETURN(EXEC).

Enter all items in Sample 1 of example.

DISPLAYS	INSTRUCTIONS
13. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-10 IS DATA OK (Y OR N) ?_	13. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step, or to enter more data, go to step 11. If 'N', go to Section IV.

NOTE:

Follow steps 11-13 to enter all samples. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC). For System A only: The program is written to handle multi-volume files of data. The program contains a constant value that dictates the number of data records which can be stored per tape cassette. Once this number of records has been written, the volume is closed, and the following example instructions are displayed, after data cassette 1 has been rewound.

(Note continued)

Example

Measure the correlation between the following samples:

N = 10   k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS
	a. REMOVE AND LABEL VOL. 1 OF FILE NPS1F250 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_ b. MOUNT SCRATCH VOL. TO BECOME VOL. 2 OF FILE NPS1F250 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_
14. REMOVE AND LABEL VOL 1 OF FILE NPS1F250 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	14. After labeling the cassette, touch RETURN(EXEC). (For the System S, the file name is NSS1F250.)
15. DO YOU WISH TO EXECUTE PROGRAM (Y OR N) ?_	15. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 19.
16. ENTER OUTPUT DEVICE TYPE SYMBOL ?_ FOR CRT ONLY, KEY RETURN(EXEC) FOR HIGH SPEED, KEY 'HS' FOR THERMAL, KEY 'TH' FOR PLOTTER(2202), KEY 'P' FOR TYPEWRITER, KEY 'TY'	16. Enter an output device symbol and touch RETURN(EXEC).
17. MOUNT VOL 1 OF FILE NPS1F250 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	17. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F250.)

Example

Measure the correlation between the following samples:

N = 10 k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS
	NOTE: If Volume 1 already is in Unit 1 from the corrections routine, ignore this step.
18a. INITIALIZATION	18a. The system now is initializing the column rank totals array.
b. CREATING WORK AREAS	b. The system now is creating work areas (This message appears for each sample.)
c. SORTING DATA	c. The system now is sorting the data. (This message appears for each sample.)
d. SETTING UP AVERAGE RANKS	d. The system now is setting up average ranks. (Tis message appears for each sample.)
e. ALIGNING AVERAGE RANKS	e. The system now is aligning average ranks. (This message appears for each sample.)
f. EXECUTING PROGRAM	f. The system now is executing the Kendall Coefficient of Concordance Test.
19. STOP END OF PROGRAM :_	19. The test results are displayed for verification.
	20. To rerun test: Touch RESET. Touch RUN and RETURN(EXEC). Go to step 2.

Example

Measure the correlation between the following samples:

N = 10   k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS

SECTION I
DATA FROM STORAGE

DISPLAYS	INSTRUCTIONS
A. INPUT INFORMATION DO YOU WISH TO CORRECT A DATA CASSETTE (Y OR N) ?_	A. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to the next step. If 'N', go to step 16.
B. MOUNT VOL 1 OF FILE NPS1F250 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). (For the System S, the file name is NSS1F250. Go to Section II.)
C. ENTER # OF TAPE DRIVES (1 OR 2) ?_	C. Enter 1 or 2 and touch RETURN (EXEC). If 1, go to Section II. If 2, go to Section III.

SECTION II
ONE TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. SAMPLE # IN ERROR (0 IF END) ?_	A. Enter the sample in error or 0 and touch RETURN(EXEC). If a sample number is entered, go to the next step. If '0', go to step 15. NOTE: If the data file contains more than one volume, the program determines the location of the record and displays the appropriate volume to mount; see Step B. For the System S, ignore this step.

Example

Measure the correlation between the following samples:

N = 10 k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS
B. MOUNT VOL 2 OF FILE NPS1F250 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC).
C. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-10 IS DATA OK (Y OR N) ?_	C. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section II. If 'N', go to Section IV. NOTE: Follow steps A-C for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN(EXEC).

SECTION III
TWO TAPE DRIVE CORRECTION

DISPLAYS	INSTRUCTIONS
A. SAMPLE # IN ERROR (0 IF END) ?_	A. Enter the sample in error or 0 and touch RETURN(EXEC). If a sample number is entered, go to the next step. If '0', go to step 15. NOTE: Sample numbers must be entered sequentially.

Example

Measure the correlation between the following samples:

N = 10   k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS
B. MOUNT VOL 2 OF FILE NPS1F250 - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	B. Mount the indicated cassette and touch RETURN(EXEC). NOTE: This prompt only appears when the sample selected is not located in Volume 1.
C. MOUNT SCRATCH VOL TO BECOME VOL 1 OF FILE NPS1F250 - UNIT 2. KEY RETURN(EXEC) TO RESUME ?_	C. Mount a scratch cassette in unit 2 and touch RETURN(EXEC).
D. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-10 IS DATA OK (Y OR N) ?_	D. Enter 'Y' or 'N' and touch RETURN(EXEC). If 'Y', go to step A of Section III. If 'N', go to Section IV. NOTE: Follow steps A-D for all corrections. The input data is displayed for verification. If more than 32 items are entered, only the first 32 are displayed. To view the remaining items, enter 'Y' and touch RETURN (EXEC).

SECTION IV
DATA CORRECTION

A. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-10 ENTER ITEM # OF BAD DATA ?_	A. Counting from left to right enter the number of the item in error and touch RETURN(EXEC).

Example

Measure the correlation between the following samples:

N = 10 k = 3

	1	2	3	4	5	6	7	8	9	10
1	1	8	3	8	5	14	11	17	14	19
2	16	1	16	36	36	71	81	56	91	56
3	5	1	7	7	7	7	29	29	29	37

DISPLAYS	INSTRUCTIONS
	NOTE: If the sample selected contains only one item, ignore this step.
B. CORRECTION ROUTINE FOR SAMPLE 1, ITEMS #1-10 ENTER CORRECT DATA VALUE ?_	B. Enter the correct data value and touch RETURN(EXEC).
	NOTE: Follow steps A and B for all samples. If proceeding from step 13, that step reappears; follow the appropriate operating instructions. If proceeding from either step C of Section II or step D of Section III, one of those steps reappears; follow the appropriate operating instructions.

Sample Output

```
THE KENDALL COEFFICIENT OF CONCORDANCE TEST
PROJECT: WRITER TEST RUN
RUN BY: B.  WRIGHT
DATE: 4/2/75

# OF SAMPLES =  3
 SAMPLE SIZE =  10

INPUT DATA/RANK VALUES:

SAMPLE 1
 1              8              3              8              5
 14             11             17             14             19


 1              4. 5           2              4. 5           3
 7. 5           6              9              7. 5           10

SAMPLE 2
 16             1              16             36             36
 71             81             56             91             56


 2. 5           1              2. 5           4. 5           4 5
 8              9              6. 5           10             6 5

SAMPLE 3
 5              1              7              7              7
 7              29             29             29             37


 2              1              4. 5           4. 5           4 5
 4. 5           8              8              8              10



THE KENDALL COEFFICIENT OF CONCORDANCE TEST
PROJECT: WRITER TEST RUN
RUN BY. B   WRIGHT
DATE  4/2/75

# OF SAMPLES =  3
 SAMPLE SIZE =  10

SUM OF R =  165
       S =  591

W(U) =  . 7959595959596          CT =  9. 5
W(C) =  . 827731092437

CHI-SQUARE =  21. 49090909091
      D. F.  =  9


END OF PROGRAM
```

APPENDIX A: ERROR MESSAGES

ERR 01, 02:

1. Operating System A on an 8K machine contrary to published limits.

2. Using maximum parameters that exceed the published limits. Touch RESET and enter new maximum parameters.

ERR 03:

1. Entering parameters through the keyboard that result in a math error; for example, when zero degrees of freedom result in division by zero. Press REWIND and start over, after checking that your experiment fits the conditions of the program.

ERR 18:

1. Using a dimension greater than 255 in an array.

2. In a two-dimensional array, using dimensions whose product is greater than 4096. Touch RESET and reenter DIM Statement.

ERR 23:

1. Keying RUN, EXEC, when there is no program in memory. Start over.

ERR 29:

1. Entering a letter or other symbol when a number is required. Key the number requested, EXEC. Continue to follow displayed instructions.

ERR 43:

1. Using an unscratched tape cassette when requested to mount a scratch volume. Press REWIND, and start over.

2. Using an incomplete data file created by removing a data tape cassette from a unit before instructed to do so. The file is no good and must be recreated.

3. Attempting to read numeric data into alphanumeric variables or vice versa. Usually occurs when the tape is not positioned correctly. Press REWIND and start again.

ERR 48:

1. Depressing a Special Function key not in the range from 01 to 11. Depress the correct Special Function key and continue to follow displayed instructions.

ERR 49:

1. Using other than the correct System Tape Cassette. Press REWIND and start over.

2. Leaving door of tape cassette drive open. Press REWIND, and start over.

3. In the System S, exceeding the published maximum number of records per cassette. Press REWIND and start over.

ERR 50:

1. Leaving the protected System Tape Cassette in the unit instead of removing it when instructed. Press REWIND and start over.

2. Using a protected tape cassette for a scratch cassette. Press REWIND, remove the tape cassette, cover the holes on the bottom by turning over the colored flaps or using cellophane tape, and start over.

INCORRECT VOL.:

1. Wrong volume or wrong file. Mount the volume and file requested by the display and touch RETURN(EXEC).

RE-ENTER:

1. Entering other than the letters requested, when alphabetic entries are required.

2. Exceeding the number of letters indicated by dashes.

3. Asking for a record not on the tape, when correcting a data tape.

4. Using two tape cassette drives when correcting a data tape; not entering the record numbers in sequence from lowest to highest.

   Enter the correct response and proceed.

SEQUENCE ERROR:

1. Because of an attempt to run the program starting from a statement other than the first, the records are not stored in orderly sequence from i to i, j to j, and so on. The data cannot be used and must be reentered through the keyboard.

ERROR CONDITIONS:

1. Using two tape cassette drives when correcting a data tape. If the processing light stays on, but nothing else happens, turn on the second tape cassette drive.

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WANG EUROPE, S.A.
Buurtweg 13
9412 Ottergem
Belgium
TELEPHONE 053/704514
Telex: 26077

WANG DO BRASIL COMPUTADORES LTDA.
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WANG INTERNATIONAL TRADE, INC.
836 North Street
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WANG SKANDINAVISKA AB
Fredsgatan 17, Box 122
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WANG COMPUTER PTY. LTD.
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WANG ELECTRONICS LTD.
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Telex: 923498

WANG FRANCE S.A.R.L.
Tour Galleni, 1
78/80 Ave. Galleni
93170, Bagnolet, France
TELEPHONE 33.1.3601212
Telex: 68958

WANG LABORATORIES GMBH
Moselstrasse 4
6000 Frankfurt AM Main
West Germany
TELEPHONE (0611) 252061
Telex: 04-16246

WANG COMPUTER SERVICES
836 North Street
Tewksbury, Massachusetts 01876
TELEPHONE (617) 851-4111
TWX 710-343-6769
Telex: 94-7421

24 Mill Street
Arlington, Massachusetts 02174
TELEPHONE (617) 648-8550

WANG LABORATORIES, INC.
836 NORTH STREET, TEWKSBURY, MASSACHUSETTS 01876, TEL (617) 851-4111, TWX 710 343-6769, TELEX 94-7421

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