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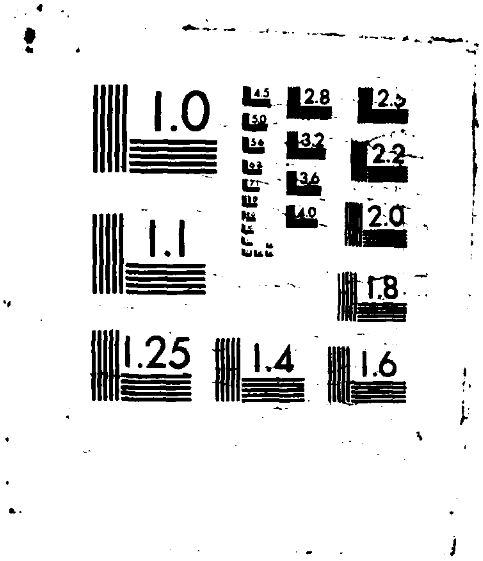
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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A MENU DRIVEN SOFTWARE PACKAGE
ON NONPARAMETRIC STATISTICS
FOR THE TANDY RADIO SHACK MODEL 100 COMPUTER

by

Susan L. Quensel

September 1986

Thesis Advisor: Donald R. Barr
Co-advisor: Charles W. Hutchins

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This thesis contains a software package and user documentation for use in solving nonparametric statistics problems. The following 11 tests are considered: Binomial test, Sign test, Cox-Stuart test, Quantile test, Quantile Confidence Intervals, McNemar test (N > 20), Tolerance Limits, Cochran test, Chi Square test, Median Test, and Chi Square Goodness of fit tests. The programs are in BASIC and are designed specifically for use on the Tandy Radio Shack M100 microcomputer.

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A Menu Driven Software Package on Nonparametric Statistics for the Tandy Radio Shack Model 100 Computer

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ABSTRACT

This thesis contains a software package and user documentation for use in solving nonparametric statistics problems. The following 11 tests are considered: Binomial test, Sign test, Cox- Stuart test, Quantile test, Quantile Confidence Intervals, McNemar test ($N \geq 20$), Tolerance Limits, Cochran test, Chi Square test, Median Test, and Chi Square Goodness of fit tests. The programs are in BASIC and are designed specifically for use on the Tandy Radio Shack *M100 microcomputer*.

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I. INTRODUCTION

Nonparametric statistics is an area in which mastery requires the solution of numerous time consuming problem sets. Because of this, students sometimes do not master the techniques. Thus the first purpose of this thesis is to provide a software package to assist students in solving problems involving eleven nonparametric tests.

The programs are written for the Tandy Radio Shack M100, a laptop computer with 24k RAM. These computers, complete with a communications cable, an AC adapter, and an owner's manual are issued to students in the Operations Research Department at the Naval Postgraduate School. However, for various reasons, they are underutilized. This thesis will provide the students with programs which are directly applicable to course work, thus improving utilization.

II. PROGRAM DESIGN ISSUES

This Chapter presents a brief overview of the design decisions made in developing the software.

A. EQUIPMENT AND LANGUAGE

The M100 computer was selected, since this is the laptop portable issued to the students. The software package was written in BASIC for several reasons. First, BASIC is the ROM resident language available on the M100. This was the most important reason for its selection. Also, the most common microcomputer language is BASIC [Ref. 1:p. 185]. Although the modules were written in a BASIC specific to the M100, they could be modified with relative ease to run on other microcomputers. The use of assembly language would not have made the programs significantly smaller, since over 50% of the program is used for screen displays.

B. KNOWLEDGE LEVEL OF THE USER

It was assumed that the primary user of the software package will have had the three course series in parametric statistics taught at the Naval Postgraduate School, and will either have completed, or be currently enrolled in a nonparametrics course. It is also assumed that the user will have had exposure to the IBM 370 and microcomputers before attempting to use the programs.

C. SELECTION OF TESTS

This software package was designed specifically to accompany and parallel the main statistical tests covered in chapters three and four of the Conover text on nonparametrics used at the Naval Postgraduate School [Ref. 2:pp. 95 - 212]. It is hoped that the programs will be immediately applicable to course work being taught here. Not all tests from these two chapters were included, because the limited memory capacity of the M100 restricts the number of programs which could be included and still permit an easy transfer of programs from the mainframe via the modem.

D. SCREEN DISPLAYS

Some of the design concepts used in programs for Computer Assisted Instruction were employed in the screen displays and module structures. The interactive screen displays were designed to avoid excessive verbiage and an attempt was made to vary screen displays in order to maintain the interest of the user [Ref. 3:p. 29]. To provide the user with the feeling of control over the programs, all the screen displays remain available for viewing until input is received from the user to indicate that he wishes to proceed.

The modules were designed as single level menu driven programs. This is appropriate because the software package is designed to accompany a textbook as a learning aid for students. In addition, multi-level menus require additional RAM which is not available on the OR department's M100 machines.

The problem solving approaches used in the programs follow those in the textbook. The same logic patterns were employed in the approach to each problem in order to improve the problem solving techniques of the students using the programs [Ref. 1:pp. 298 - 305].

E. DESIGN OF THE USER'S MANUAL

The user's documentation is divided into four sections. The first contains the information needed by a novice user to download the programs from the mainframe using the M100 (See Appendix A). Next are the general instructions on the module programs, and example problems of each test with screen displays shown. Most of the example problems included demonstrate the application of nonparametric statistics to military problems. This portion of the documentation is included as the User's Manual in Appendix B. The final two portions of the documentation cover possible problems with the programs and procedures for redimensioning arrays. (See Appendix C and D).

III. DISCUSSION OF THE PROGRAM MODULES

A. GENERAL

The package has 5 subsections. The first contains information on downloading programs from the mainframe, a user's manual for the programs, instructions on redimensioning the program arrays, and possible solutions to program run errors. This document is designated CONOVER SCRIPT, and is available on the mainframe "M100" disk. This subsection is designed to be printed using the Naval Postgraduate School laser printer from a 3278 terminal.

The last four components are the actual programs themselves. These routines are stored as BINOMA SCRIPT, BINOMB SCRIPT for the tests covered in chapter 3 of Conover and CHISQA SCRIPT and CHISQB SCRIPT for the tests derived from the chi square distribution covered in chapters 3 and 4 of Conover. [Ref. 2:pp. 95 - 212]. These modules are also located on the "M100" disk.

B. PROGRAMS

1. Binomial Modules

BINOMA and BINOMB compose the two subpackages which must be downloaded in order to calculate the solutions to problems using the following procedures:

1. Binomial Test,
2. Quantile Test,
3. Sign Test,
4. Cox-Stuart Test,
5. Quantile Confidence Interval.

The user is prompted to input values needed in order to calculate the test statistic, and is also permitted to select one-sided or two-sided test. The user may also select any type I error rate (Alpha) desired in conducting the hypothesis test. The Alpha value returned by the machine is rounded down if the user's alpha cannot be determined exactly, due to discreteness. After the calculations of the hypothesis test, the user is given the opportunity to calculate the actual significance level (Alpha Hat) based on the sample data, return to perform another test, or breakout to the M100 main menu.

2. **Chi Square Module**

The CHISQA and CHISQB cover six procedures which use the chi square distribution. These are covered in Chapters 3 and 4 of the Conover text [Ref. 2:pp. 95 - 212]. These are as follows:

1. Tolerance Limits,
2. McNemar Test,
3. Cochran Test,
4. Median Test,
5. Chi Square Test,
6. Goodness of Fit Test.

Unlike the Binomial programs, these procedures require sample data for the performance of calculations. Yates' correction for continuity is not included, since this is Conover's recommendation [Ref. 2:p. 149]. At the conclusion of the calculations for each test, the user is provided the value of the test statistic and the alpha-hat value (level of significance) associated with that test statistic. The user can determine if the alpha-hat value is small enough for the rejection of the null hypothesis. In the case of Goodness of Fit tests, the program tests only normal, poisson, and uniform hypotheses. In both the normal and the poisson cases, the degrees of freedom are adjusted if parameters are estimated from the sample data.

IV. AREAS FOR FURTHER WORK

There are several possible extensions of this work. It would be useful to have programs for the tests in Chapters 5 and 6 of the Conover text, on additional modules [Ref. 2:pp. 213 - 385]. This would provide programs which would parallel the entire course in nonparametrics as it is taught at the Naval Postgraduate School.

If the RAM capacity were upgraded to 32k on the M100 machines, the programs could be collapsed into fewer modules. This would simplify the transfer of the programs via modem.

The programs themselves are written in an M100 version of MS BASIC. These programs could be converted to run in GW BASIC or other MS BASIC versions, for use on other microcomputers.

APPENDIX A
DOWNLOADING INSTRUCTIONS

General

The following instructions are provided in addition to those included in Tandy Owner's Manual [Ref. 4:pp. 75 -96], to assist you in interfacing with the IBM 370 at the Naval Postgraduate School, and to more efficiently download the "BINOM" and the "CHISQ" modules located on the M100 library. If you have previously downloaded programs, and your A-disk contains the necessary files, you will wish to skip the first section of these instructions and go directly to the instructions on the modules themselves.

Preparing Your A-Disk

Before attempting to download any programs from the M100 library, you should perform the following actions from a standard 3278 terminal [Ref. 5:p. 1].

1. Add a **LINKM100 EXEC** to your A-disk. It should contain the following lines:

```
CP LINK 0344p 195 295 M100
ACC 295 B
```

2. From the CMS mode, link to the M100 library using the **LINKM100** command. You should either create a **Profile Exec** identical to the the Profile Exec located in the M100 library, or augment your present Profile Exec with the instructions on the M100 Profile Exec [Ref. 5:p. 1]. The simplest way to do this is to enter the **Xedit Profile Exec** and use the command **GET PROFILE EXEC B1.**

If you expect to upload files, you should create or augment your **Profile Xedit** with the Profile Xedit information from the M100 library in the same fashion that you modified your Profile Exec. (Note - be certain that your Profile contains **Set Linedit off** in order to prevent data transfer problems.)

While at your terminal, if you would like to examine any of the files located in the M100 library, simply type **flist * * B** and use the "Browse" command, since this is a read only disk. These are the only changes to your A-disk which are necessary to use your M100 from home to download M100 library programs.

Downloading Procedures Using the TELCOM Program

Initially, it will be necessary to use the ROM resident *TELCOM* package on the M100 to download the CMSCOMMS program. This program, written by James Eagle, simplifies the M100 interface with the IBM 370. This program will be used to download the program modules from the mainframe.

You will find the instructions on setting the switches, and connecting your M100 with the modem in the Tandy Owner's Manual [Ref. 4:pp. 76-77]. After connecting the modem cable to the M100 and your telephone, use the following procedures to download programs using *TELCOM*.

STEP 1A:

Turn on the M100 and access the *TELCOM* program. (The *"label"* keys above the keyboard will automatically display the assigned function key labels) [Ref. 4:p. 79]

STEP 2A:

Strike the *"f2"* key function key. The word *"CALL"* will be displayed. Enter the following numbers and symbols exactly as they appear here:

```
6463025<>
```

(The extra symbols (< >) are required.) Strike the "enter" key. The M100 will dial the number. When the connection is being made with the IBM, you will hear an audible beep. (If you do not get a beep, the M100 you have has had the command "Sound Off" input. If you want to turn it back on, see the Owner's Manual) [Ref. 4:p. 123]. When the connection is established, the beeping stops and the the screen displays *"VM/370 ONLINE"*.

Strike the "enter" key. An exclamation mark (!) will appear on the left side of your screen, and a period (.) will appear on the right. The period (.) is the "ready" prompt. You may now logon the system using normal procedures. (Note transmissions from the mainframe are split between lines, with the first character of each line displayed at the right side of the screen. The "CMSCOMMS" software package will eliminates this inconvenience.)

When the machine queries you for your password, first a row of "***" are printed, then these symbols are overprinted by a series of "**HHH**". Finally the machine will print a series of "**SSS**" proceeded with a period (.). You should not attempt to input your password until the "SSS" series has completed printing. If you receive an error message, reinitiate the logon procedure. (Note - the mainframe will transmit an error when you input a line in which you have backspaced to correct a character.)

STEP 3A:

The word *"Half"* should be displayed above the *"f4"* key. If it is not, strike the *"f4"* function key once.

STEP 4A:

If the screen has not yet indicated that *"CMS"* is on line, enter either *I CMS*, or *B*.

STEP 5A:

Link to the M100 library by typing *LINKM100*. If you would like to examine the CMSCOMMS file before downloading it, input *TYPE CMSCOMMS JNE B1*, and strike the "enter" key. This allows you to "Browse" the file as it scrolls on the terminal screen. The *"WAIT"* command will be displayed on the bottom of the screen above the *"f6"* key while the file scrolls. When the end of file is reached, the *"WAIT"* display disappears, and the machine will return an *"R"* on the right side of the screen. This indicates that you are now in *CMS*.

STEP 6A:

Strike the *"f2"* function key for *"down"*. The M100 will query you *"File to be downloaded?"*. You may type in any 6 letters you wish to use to designate the file name to be used in the M100 RAM file directory. It is suggested that you select the name CMSCOM, since we have used this name throughout these directions. Type the name and strike the "enter" key. This will cause the *"down"* label on the bottom of the M100 display to change to reverse video. We are now ready to transfer the file.

STEP 7A:

Type in *TYPE CMSCOMMS JNE B1*, and strike the "enter" key. The program you saw in Step 5 should scroll on the screen. If you accidentally typed the line before the "ready" prompt was displayed, you will receive an error. Wait for the return of the prompt (.) and reenter your line. If your download is uneventful, wait until you receive an *"R"* from the IBM, indicating it has returned to CMS. This *"R"* will be displayed on the right side of the screen. Strike the *"f2"* for the *"down"* function key again. The *"down"* which was previously displayed in reverse video, will now go back to normal video.

STEP 8A:

The transfer is complete and you may logoff the mainframe. Type *LOGOFF* and the IBM will return the session statistics. When it has completed, input *"BYE"* by striking the *"f8"* key. The machine will query with *"disconnect?"*. Respond with *YES*, or *Y*, and strike the "enter" key. The function keys labels will change. We return to the M100 main *"menu"*, by striking the *"f8"*key.

Converting An ASCII File to a Basic Program on the M100

The file "CMSCOM.DO" is now displayed on the M100 main menu. The ".DO" indicates that the file is in ASCII or character format. To run the program as a BASIC program, we must use the text editor to eliminate the heading and trailing "garbage" associated with the data transfer, and remove unnecessary carriage returns. **IF YOU ARE INEXPERIENCED WITH THE TEXT EDITOR REFER TO THE TANDY OWNER MANUAL PAGES 43 - 58. Pages 53 and 54 deal specifically with deleting text.**

STEP 1B:

Enter the CMSCOM document file and remove heading material, using the text editor, until the first numbered program line showing reads as follows:

```
1 CLS: PRINT"          Terminal Package for
 CMS":PRINT
```

Strike <control key> and the down arrow above the keyboard to go to the end of file. Here remove trailing material until the last line reads:

```
702 CLOSE:MAXFILES=1:MENU
```

STEP 2B:

Leave the text editor by striking *"f8"*. Now enter the *BASIC* program and type the following command exactly as shown:

```
LOAD "CMSCOM.DO"  <enter key>
```

The word "Wait" will flash off and on in reverse video as the program is being compiled. When the M100 returns an *"OK"*, it means your program has loaded correctly. (If instead of an *"OK"* after the flashing *"Wait"*, you receive an error message, this indicates that you have some carriage returns (the carat symbols) at locations other than at the end of lines. You will need to return to the "CMSCOM.DO" and scroll through it using the text editor to eliminate unnecessary carriage returns.) *"SAVE"* the BASIC program as a RAM file, by typing in exactly the following:

```
SAVE "CMSCOM"  <enter key>
```

The M100 will respond with another *"OK"*. You may now strike *"f8"* and return to the main menu. Both the document program and the basic program will be shown as RAM programs. Erase the document program by entering BASIC and typing the following:

```
KILL "CMSCOM.DO"  <enter key>
```

You now have the program "CMSCOM.BA" in your M100 and can proceed to download the program modules.

Note that you may wish to also download the program CROUT JNE B1 from the M100 library. This can be used to remove *"most"* of the extra carriage returns from downloaded ASCII files. You will not need to use this program with the program modules, because they have been designed with lines of 80 characters or less.

Downloading the BINOM and CHISQ Program Modules
Using the CMSCOM.BA Program

BEFORE ATTEMPTING TO DOWNLOAD MODULES ERASE ALL PROGRAMS EXCEPT CMSCOM.BA, and CROUT.BA. Failure to do so will cause your machine to exceed its' 24k memory capability.

Since interfacing with the NPS mainframe is simplified by using the *CMSCOM.BA* program written by James Eagle, we will use it to download the program modules. The steps to use are as follows:

STEP 1C:

Run the "*CMSCOM.BA*" program by placing the cursor over this program. On the first screen, the program will ask "*On-campus call(y/n)?*". Answer N, unless you using a military phone on base. The M100 will dial the number. You will hear a "beep" or "ring" as long as the system is trying to establish a connection. When the connection has been made with the mainframe, the "beeping" will cease, and you should strike the "enter" key.

STEP 2C:

The following data will be added to the screen.

```
!463025

.
```

The period (.), as with *TELCOM*, is the "ready" prompt.

The machine is now ready for the logon procedures. These are identical to those used when you are at the standard 3278 terminal. After you have logged on, strike the "enter" key again and wait for the machine to return an "*R*" before continuing. Strike the "enter" key once more. This may take some time if the load on the mainframe is heavy. If you had a full screen shown, you would see the *RUNNING* down in the lower right hand corner of the terminal screen.

STEP 3C:

Strike the *"label"* key above the keyboard to display the function key assignments used in the program. You must now type *LINKM100*, to access the M100 library where the modules are stored.

STEP 4C:

Strike the*"f2"* key for *"down"* to begin downloading the program module. The screen will prompt you with *"File to download?"*. Enter the 6 letter designator you wish to use for the M100 file. It is recommended that if you are unfamiliar with these procedures, that you use the module names assigned in these instructions to prevent confusion. The M100 screen will now display the following line:

```
Downloading to <6 letter title> until  R entered.
```

The two programs, BINOM and CHISQ are divided into parts for data transfer to the M100. This has been done because the files, in their entirety, are too large for a novice user of the M100 to convert into BASIC easily. If you are using the binomial distribution, you must transfer both the BINOMA SCRIPT B1, and the BINOMB SCRIPT B1 files. For the Chi Square Distribution problems, transfer CHISQA SCRIPTB1, and CHISQB SCRIPT B1. We will demonstrate the download with the two BINOM modules. (Note - You must download both halves one at a time and convert them to BASIC in order to be able to use the programs.)

STEP 5C:

Strike the "enter" key to bring up the "ready" prompt (.). Next type in *TYPE BINOMA SCRIPT B1 <enter key>*. The program you are downloading should begin to scroll by. If there are any problems and the program does not begin, strike *<control key> R*, and respond to the screen display *"Press any key for Terminal Mode"*. After this go to STEP 4C and try again. The program modules are relatively long, so they will take approximately 5-7 minutes to complete the data transmission.

STEP 6C:

The receipt of an "*R*", means we are now in the *CMS* mode and that we can input <*control key*> *R*, and *Press any key to return to the terminal mode.*

STEP 7C:

Wait for the "ready" prompt, then LOGOFF. The M100 will return a dotted cursor. Strike the "*f8*" to disconnect and return to computer mode.

Module Conversion to BASIC

These instructions are very similar to those used to convert the CMSCOM.BA program presented, except when the second module is converted, and "pasted" onto the first submodule. These instructions should be followed closely or you may get an OM (Out of Memory) error.

STEP 1D:

Enter the BINOMA document file, and with the text editor remove the extemporaneous heading and trailing information which will prevent its operation as a BASIC program. When you complete this operation, the first and last lines respectively, should read as follows:

```
100 CLS
14000 '****  CALCULATION OF ACTUAL ALPHA HATS
```

Leave the text editor and enter the *BASIC* program by striking "*f8*" for the "*menu*" and then the <*enter key*>. In BASIC type the following command.

```
LOAD "BINOMA.DO"  <enter key>
```

The word "WAIT" will flash off and on in reverse video as the program compiles. When the M100 returns an "*OK*", it means your program has loaded correctly. (An error message, indicates that you have some unnecessary carriage returns in the document. You will need to return to the "BINOM.DO" and scroll through it using the text editor to eliminate unnecessary carriage returns. This should not happen unless you had transmission errors.) *"SAVE"* the BASIC program as a RAM file, by typing in the following:

```
SAVE "BINOMA" <enter key>
```

The M100 will respond with another *"OK"*. Strike *"f8"* and return to the main menu. Check to ensure that you have both the document program and the basic program shown as RAM programs. Enter the BINOMA.BA. The program should immediately begin to run. To escape from the program hold down the *<shift key>* and strike the *<break key>* above the keyboard, or use *<control key>* C , followed by *"f8"* to leave the program. If you have an error, examine the program using either the "LIST" command [Ref. 4:pp. 152-153], or the text editor. If the program executed, however, erase the document version by entering BASIC and typing the following:

```
KILL "BINOMA.DO" <enter key>
```

To download the next submodule repeat STEPS C1 through C7. After the submodule BINOMB.DO is downloaded, follow the procedures listed below to add it to the BINOMA.BA program.

STEP 2D:

Enter the BINOMB.DO file and eliminate the unnecessary information. The first and last lines should be as listed below

```
14020 ON QT GOTO 14040,14300,14040,13100,14040
18770 PRINTTAB(5) "reject your null hypothesis if":RETURN
```

STEP 3D:

We will now "paste" the two files together.

1. Move the cursor to the top of the BINOM.DO file. and strike *< enter key >*.
2. Turn the *"labels"* on, using the *"label"* button.

3. Strike "*f7*" to "select" text for copying.
4. Strike <*control key*> and hold while striking the <*down*> *cursor arrow.*

The cursor will go to the end of the file, and the entire file will be highlighted in reverse video.

5. Strike the "f6" to cut the program to the "*paste*" buffer of the M100.
6. Strike "f8", wait for an "OK", then strike "f8" again to return to the main menu.
7. Enter the "BINOMA.BA" program, then break out by either using <*control key*> C or <*shift key*> <*break key*>. An "*OK*" will appear on the screen.
8. Strike the "*Paste*" key above the keyboard, and the new program will be "*pasted*" to the previous program.

The "paste" buffer on the M100 will still contain the entire submodule. This will use an excessive amount of memory so you will want to clear the buffer by copying something short into it. (It remains full even when the machine is turned off.) To clear the buffer, use the Copy and Paste commands listed in the Tandy Owner's Manual [Ref. 4:p. 56].

You will now need to attempt to run the program to determine if the load has been successful. A "*DS*" error, indicates that you have an extra carriage return in the program which must be removed before it can operate correctly. You will need to edit the program to remove it.

This completes the transfer of the Binomial Distribution program module. To the download the Chi Square Distribution program module, simply load CHISQA SCRIPT first, and then CHISQB SCRIPT (the order is important because of memory capacities).

APPENDIX B
USER'S MANUAL

1. GENERAL INFORMATION

It is assumed that users of this software package are familiar with nonparametric statistics and computers. Since the programs are written for the TRS M100 and use the IBM 370 as a storage device, a knowledge of micros or mainframes with virtual machine interfaces is required to use the programs. If you have not yet downloaded a package module, see Appendix B on Downloading Programs before proceeding. The programs themselves have been especially designed to accompany W.J. Conover's book *Practical Nonparametric Statistics* [Ref. 2]. The symbols, notation, and organization used in the programs parallel this text very closely.

Before you attempt to use any of the programs, you should ensure that

**** The "Caps Lock" key is depressed ****

on the M100. If you fail to do this, the M100 will not respond properly to your keyboard inputs. You should also be aware of the specific meanings of phrases used on the interactive screens.

1. "Strike any Key" means keyboard keys only, not function keys, shift keys or control keys.
2. "MAKE YOUR SELECTION" requires the input of an integer number from the keyboard, not a function key, shift key, or control key.

If you strike the keys too forcefully, the machine may skip screens.

This package is composed of two software modules, "BINOM", and "CHISQ". The "BINOM" module covers tests from Chapter 3 of Conover which have the binomial as their underlying probability distribution function. The "CHISQ" module includes tests covered in Chapters 3 and 4 which are derived from the Chi Square distribution.

2. TESTS BASED ON THE BINOMIAL DISTRIBUTION

Included on the module "BINOM" are the binomial test, the quantile test and the quantile confidence interval, the Cox-Stuart test, and the sign test. Since these tests are all derived from the two parameter binomial PDF, they all require the input of an "N", and a "P^*". "N" is equal to the number of trials, and "P^*" is the expected or hypothesized probability of a "class 1" occurrence.

All the tests on this module are limited to a maximum "N" of 30, which is somewhat larger than Conover used in exact binomial calculations. To use a larger "N", you may either redimension the arrays (see Instructions on Modifying Program Modules in APPENDIX C) or you may use the Normal Approximation recommended in the Conover text for large "N". *A Normal Approximation is not included in the software module.* The tests on the module are also designed to accept only decimal values for "P", the hypothesized probability, (Note- the screen format on the M100 uses "'P'" in lieu of "P^*") and "ALPHA", the significance level.

If you wish to exit a program in progress, strike "shift" and keep this key depressed while striking the "break/pause" button above the keyboard, or the "control" key and "C". After exiting the program if you strike "f4", which is function key 4, or type "run" and strike the "enter" key the program will reinitialize. If you wish to exit to the M100 main menu after breaking out of the program, simply strike "f8", which is function key 8, or type the word "menu" and strike the "enter" key.

Once you enter the "BINOM" module the Module Main Menu will appear on the screen as follows:

```
                    MENU

     1-Binomial Test      2-Quantile Test
     3-Cox-Stuart Test    4-Quantile C.I.
               5-Sign Test
      PLEASE MAKE YOUR SELECTION <1-5>
```

The discussion and example problems for the tests are presented in this user's manual in their order of appearance on the Binomial Module Main Menu. Each test is demonstrated as a "self contained - stand alone" example, so that you may study and use them in any order you like. After you have worked through several of the tests within the module, you may find that some of the procedural information and screen explanations are redundant.

a. Binomial Test

General

The Binomial Test is used to determine the reasonableness of the assumption that a sample could have been drawn from a population having the value "P^* ", which you hypothesized in your null hypothesis.

** * Example Problem * **

Problem Setting

Suppose you have watched people rolling a certain die for a period of time, and you believe that the "five" is coming up too often. You wish to test your hypothesis statistically to determine if the die is fair. You know that if it is, then all the faces are equally likely. Your null hypothesis for any face should be

$$P^* = P = 1/6.$$

"P^* " is the constant probability you expect if the null hypothesis is true, "P" is the probability obtained when the test is conducted, and 1/6 is the probability of any given face. You roll the die "N" trials to obtain a sample to use to test your hypothesis. Suppose for our example you roll the die 12 times, and observe that the "five" occurred exactly 8 times. Given this information let's test our null hypothesis.

Computer Solution to Problem

One possible way to test this hypothesis is with the application of the Binomial Test to the data. Therefore, selection "1" is made from the Module Main Menu. (Note - it is not necessary to strike the "enter" key after making your selection.)

```
                          MENU
          1-Binomial Test      2-Quantile Test
          3-Cox-Stuart Test    4-Quantile C.I.
                      5-Sign Test
           PLEASE MAKE YOUR SELECTION <1-5> 1
```

The following screen will now appear:

```
Do you wish to check the assumptions
of the test that you have selected?

Just input 'Y' for yes or 'N' for no
```

If you wish to check the assumptions, simply enter a Capital *"Y"* otherwise you must enter a Capital *"N"*. (*The machine will remain in the loop until one of these two letters is input.*) If you input an "N" for your response, the M100 will skip the data assumption routine and request your input parameters. For the purposes of this example we will assume that your answer was "Y" to the request for information on the test assumptions. The following screen will appear:

```
You selected the Binomial Test
this test assumes you meet the
following assumptions

TO CONTINUE - STRIKE ANY KEY
```

You may strike any key except function keys, shift keys, or control keys to continue.

The following screen now will appear:

```
1-Only Nominal Level Data
2-'P' Constant Over All Trials
3-All Observations Are Independent

TO CONTINUE - STRIKE ANY KEY
If you fail the assumptions then
to return to the menu input 'M'
```

If after reading the assumptions, you decide that the Binomial would not be appropriate, input an *"M"*. This would return you to the Module Main Menu from which you may select another test. In this example however, we find that the Binomial Test is appropriate to perform on the die example data and "strike any key" to continue.

The program is now ready for the test parameter input. The first parameter requested is "*N*".

```
Please input N? 12
```

We input "12" as the number of observations or trials and strike the "enter" key. After the machine has accepted the first parameter, it will return with the following screen display requesting that you input "P^* " (the hypothesized P value).

```
Please input P(robability) .16667
```

We input the decimal value for our hypothesized probability value of 1/6.

The machine now requires input from you concerning the significance level or *Alpha level* at which you wish to test your null hypothesis. The program will accept any decimal values between 0 and 1 for Alpha. Due to the discrete nature of the Binomial Distribution and the machine program, your actual alpha will always be "equal to or less than" the alpha value which you input. We will input an alpha of .075 for our example.

```
Please input the ALPHA VAlUE .075
```

The last input request is one for information concerning the location of the critical regions. This screen requests that you input an integer indicating where you want the critical region located.

```
Please select your critical region
        1 - Two Tailed Test
        2 - Lower Tail Only
        3 - Upper Tail Only

PLEASE MAKE YOUR SELECTION <1-3>? 3
```

We elected to do an "Upper Tailed Test", *because it appeared that the* die was loaded in favor of rolling a "five" when we watched it being thrown before we conducted our trials.

Pressing the "enter" key displays the following screen which is self explanatory.

```
I'm Calculating
```

Upon completion of the calculations the screen will return with following output data.

```
  ALPHA is equal to .036378
   reject your null hypothesis if
      'T' is greater than  4
TO CONTINUE - STRIKE ANY KEY
```

The information on this screen is the output data from the *Hypothesis Test*. The test statistic 'T' is defined in Conover as "the number of times the outcome is 'class 1'" [Ref. 2:p. 97]. The 'T' presented here indicates the number of "class 1" outcomes which lie in the .036378 area of the binomial PDF. After striking any key, the M100 will inquire whether you wish to determine what your *ALPHA HAT* value is.

```
Do you wish to find your actual
ALPHA HAT VALUE?

Just input 'Y' for Yes or 'N' for No
```

The M100 will only accept a Capital *"Y"* or a Capital *"N"*. Any other entry will cause the computer to remain in the loop waiting. If the computer does not immediately respond, check to see that you have"Caps Lock" on. *DO NOT STRIKE THE ENTRY KEY AFTER INPUTING THE LETTER OR THE COMPUTER WILL SKIP A SCREEN DISPLAY.* In the case of our example problem we will input a "Y".

```
Please input your observed 'T'?  8
```

You are asked to input the number of observed "class 1" occurrences. In our example we observed 8 trials inwhich "five" appeared, so we input an "8" and then press the "enter" key.

The computer responds with the following:

```
ALPHA HAT is equal to 1.3E-05
TO CONTINUE - STRIKE ANY KEY
```

The probability of having "8" or more "fives" in 12 rolls on a fair die is a very rare event. This would occur by chance with a probability of only .000013 if the null hypothesis (i.e. that P= 1/6) were true. When we reject this null hypothesis we can do so with relatively strong confidence that we have not made a type 1 error.

We have now completed the Binomial Test, and strike a key. The following screen appears:

```
     Strike 'C' to do another test
If you are finished strike any other key
```

If you strike "C", the machine will reset itself. Do not strike the "enter" key after making your selection.

b. Quantile Test

General

The quantile test is an application of the binomial test to an ordinal level, discrete random variable. Examples are student's test scores on a given true/false or multiple choice test. You could use the Quantile test to perform an hypothesis test on sample data taken from the population of students who took the examination. Using the sample data, you can test underlying assumptions which you may have concerning the score associated with a certain quantile in the population as a whole. If you already know what scores are associated with the quantiles in the population, you may wish instead to determine if the sample you drew from the population is representative of the whole group. If the quantile associated with a given score in the sample is approximately what you would expect, based either on your assumptions or upon what you know about the group scores as a whole, you would retain your hypothesis.

* * *Example Problem* * *

Problem Setting

Suppose you have data on Army Physical Fitness Tests (APFT) from three military posts. You know the combined median scores on each of the three events were 15.6 minutes for the 2 mile run, 43 pushups, and 51 situps.

You have just tested a unit of 10 soldiers and their scores on the pushups listed below appear to be higher than the "Army Average":

38 43 43 46 51 59 60 60 61 62

Since this is a Special Forces unit, you would expect the median score achieved in this unit to be higher than the "Army Average". Formally stated our hypothesis is as follows:

$$H_0: \text{"SF" median} \leq \text{"AA" median}$$
$$H_1: \text{"SF" median} > \text{"AA" median}$$

Computer Solution to the Problem

An examination of the data would tend to indicate that the Quantile Test might be appropriate. So we chose selection "2" from the Module Main Menu.

```
                    MENU

   1-Binomial Test      2-Quantile Test
   3-Cox-Stuart Test    4-Quantile C.I.
             5-Sign Test

   PLEASE MAKE YOUR SELECTION <1-5> 2
```

(*Note that it is not necessary to strike the "enter" key after selecting the test you wish to perform* .) The following screen appears:

```
Do you wish to check the assumptions
of the test that you have selected?

Just input 'Y' for yes or 'N' for no
```

For the example, we will check the assumptions of the Quantile Test by inputing a Capital "*Y*". Inputing a Capital "*N*" causes the M100 to skip the data assumption routine and request your input parameters. This will provide you with the following two screens:

```
You selected the Quantile Test/CI
this test assumes you meet the
following assumptions

TO CONTINUE - STRIKE ANY KEY
```

```
1-Ordinal or Higher Level Data
2-All Observations Are IID

TO CONTINUE - STRIKE ANY KEY
If you fail the assumptions then
to return to the menu input 'M'
```

If you fail any of the assumptions, then you should input an *M* to return to the Module Main Menu. In this example, we meet the requirements for a Quantile Test. So we strike a key proceed with our test.

The program now requests that you input parameters to be used in the hypothesis test to be performed. The first parameter requested for input is *N*.

```
Please input N? 10
```

Ten people took the PT test, so we input the number "10" and strike the "enter" key.

The next screen requests that you input P^* ,the hypothesized probability. In the example problem, we are interested in testing the "Median", so we would input ".5".

```
Please input P(robability) .50
```

We strike the "enter" key and continue.

The M100 will now ask you for information concerning the significance level or *Alpha Level* The program will accept any decimal values between 0 and 1 for Alpha. Due to the discrete nature of the Binomial Distribution and the machine program, your actual alpha will be "equal to or less than" the alpha value which you input. We will arbitrarily select an Alpha of .10 for this example.

```
Please input the ALPHA VA1UE .10
```

The final request for parameters concerns the location of the critical regions. You can chose a two tailed or a one tailed test. *This step should be performed carefully, since it is easy to make an error here when doing a Quantile Test.* We believe that our small group of ten individuals will have a median score higher than the "Army Average", so we need to perform a one tailed hypothesis test. We expect that if we rank order the scores of our sample and calculate a CDF, the *percentile for the Army Average median score (43)* will be lower than .5 when that score is encountered in our sample set. Therefore we select a *"Lower Tailed Test"* and enter selection "2" as our choice.

```
Please select your critical region
      1 - Two Tailed Test
      2 - Lower Tail Only
      3 - Upper Tail Only

PLEASE MAKE YOUR SELECTION <1-3>? 2
```

We have made our selection now and strike the "enter" key.

While the Binomial Probability computation is in progress the screen will display:

```
I'm Calculating
```

Upon completion of the calculations the following screen will appear:

```
ALPHA is equal to .0546875
., reject your null hypothesis if
'T1'is less than or equal to  2
TO CONTINUE - STRIKE ANY KEY
```

The "'T1'" is the number of observations which are *"less than or equal to* X^{*}" [Ref. 2:p. 107]. This screen would be different if you had selected an upper tailed or a two tailed test. In the case of an upper tailed test, "'T2'" would be displayed rather than "'T1'". The "'T2'" value is the number of observations that are *"less than* X^{*}" [Ref. 2:p. 107]. You would reject your null hypothesis if your observed "'T2'" value was larger than the screen value "'T2'" displayed. If a two tailed test had been selected, both "'T1'" and "'T2'" would have been displayed. You would be seeking either values smaller than "'T1'" or larger than "'T2'". After striking any key, the M100 will inquire whether you wish to determine what you *ALPHA HAT* value is.

```
Do you wish to find your actual
ALPHA HAT VALUE?

Just input 'Y' for Yes or 'N' for No
```

If your response were Capital "N" then the M100 would simply go to the final screen. For the example, we will request the actual APLHA HAT value, so we input a Capital 'Y'. (Note - you do not need to strike the "enter" key as the machine will accept the input without it.) The machine requires the input of your actual observed "'T1'" and "'T2'". In this example X^{*} is the "Army Average" median score. In our data on the number of pushups, we had "3" scores equal to or less than the median score of 43, and "1" score less than 43. These values are input on two successive screens which appear as follows:

```
Please input your observed 'T1? 3
```

```
Please input your observed 'T2'? 1
```

(Note - *inputing a "'T2'" value which is larger than "'T1'" gives a machine error.*)

The computer responds with the following output screen indicating ALPHA HAT, based on the observed data. The probability of having a "'T1'" value less than or equal to 3, if the true median score is 43, would occur by chance with probability of .171875. Our "'T1'" value was too large to reject our null hypothesis at an alpha level smaller than .171875.

```
ALPHA HAT is equal to .171875
TO CONTINUE - STRIKE ANY KEY
```

We have completed the Quantile Test. We strike a key and the following screen appears:

```
Strike 'C' to do another test
If you are finished strike any other key
```

If you strike "C", the machine resets itself to the Module Main Menu. The input of any other key prepares the machine to receive either the typed entry "Menu", or the input of "f8" function key to return to the M100 main menu.

|c. |Sign Test

General

The Sign Test, as treated by Conover, is based on a binomial test with P^* set to 1/2. The sign test is used with related samples. The most common of these related samples are either "before" and "after" data samples or matched pairs. Let's examine a problem which will explain the sign test procedures.

* **Example Problem* * *

Problem Setting

Say you have 10 sets of identical twins, and you believe that "first born" twins are more aggressive and dominant than the "second born". To test this you develop and administer a psychological profile battery to get an aggression scale for each of the 20 people in the survey. After completing your analysis, you got the following scores on a scale from 1 to 10 on the aggression index.

CASE	(First Born) Y SCORE	(Second Born) X SCORE	Associated Sign
1	6	3	+
2	7	6	+
3	4	3	+
4	5	2	+
5	9	6	+
6	7	2	+
7	10	9	+
8	2	2	
9	5	5	
10	3	4	-

You are interested in determining if our inital hypothesis is true. Stated formally, the hypothesis would be as follows:

$$H_0: P(+) \leq P(-)$$
$$H_1: P(+) > P(-)$$

Computer Solution to Problem

We have ordinal level data from 10 matched pairs; therefore, we select "5" from the Module Main Menu. (Note that it is not necessary to strike the "enter" key after selecting your test.)

```
                 MENU

1-Binomial Test        2-Quantile Test
3-Cox-Stuart Test      4-Quantile C.I.
             5-Sign Test

  PLEASE MAKE YOUR SELECTION <1-5> 5
```

The M100 now asks you if you wish to check our assumptions.

```
Do you wish to check the assumptions
of the test that you have selected?

Just input 'Y' for yes or 'N' for no
```

If you wish to check the assumptions, simply enter a Capital "*Y*" otherwise you must enter a Capital "*N*". (*The machine will remain in the loop until one of these two letters is input.*) If you input an "N" for your response, the M100 will skip the data assumption routine and request your input parameters. For the purposes of this example we will assume that our answer was "Y" to the request for information on the test assumptions. The following screen will appear:

```
      You selected the Sign Test
    this test assumes you meet the
        following assumptions

    TO CONTINUE - STRIKE ANY KEY
```

At this time you may strike any key except the function keys located above the keyboard, the shift keys, or the control keys in order to continue.

The following screen listing the assumptions of the sign test will now appear.

```
1-Ordinal or Higher Level Data
2-Paired Observations
3-Outcomes in 2 Classes (+, or -)
4-Cases IID Within Classes
TO CONTINUE - STRIKE ANY KEY
If you fail the assumptions then
to return to the menu input 'M'
```

You know you have paired data, since the twins are naturally matched. The aggression scores represent ordinal level data; therefore, it would seem that you do meet the assumptions of a sign test. You continue by "striking a key".

The machine will now query you for the parameters needed to perform the test. In the sign test, you are interested in the number of times *"X is Less than Y"* and *"X is Greater than Y"*.In this example, we classified second born as X, and first born as Y. This classification was arbitrary. If the classification were reversed, the choice of a tail location on a one tailed test would have to be switched. We eliminate the number of times that *"X is equal to Y"* by omitting any ties in the paired data.

```
Input the # of times X<Y (+)  7
```

We input a "7" here because there were seven times that the "X" aggression scores were lower than the "Y" aggression score.

The next screen appears which requests the information concerning the reverse situation.

```
Input the # of times X>Y (-)  1
```

We input an "1" and strike the "enter" key to continue. We input this number because among our 10 sets of twins, in only one case did the second born twin have a higher aggression score.

Now the M100 will request input from you concerning the significance level or *Alpha Level* at which you wish to test your null hypothesis. It will accept any decimal value between 0 and 1 for alpha.

```
Please input the ALPHA VAlUE .10
```

The Binomial Distribution is discrete, and the machine has been programmed to ensure that your actual alpha will always be "equal to or less than" the alpha value which you input. We input .10 for our example.

The final input request concerns the location of your critical regions. This screen requests you input an integer indicating where you want the critical region located. You can chose a two tailed test or a one tailed test. *This step should be performed carefully*, as the assignment of X and Y directly influence the location of the critical region. The tail that we wish to examine is the *"Upper Tailed Test"* because we want to place our original conjecture on trial.

```
Please select your critical region
          1 - Two Tailed Test
          2 - Lower Tail Only
          3 - Upper Tail Only

PLEASE MAKE YOUR SELECTION <1-3>? 3
```

We input a "3" for the upper tailed test.

The next screen is self explanatory.

```
I'm Calculating
```

Upon completion of the calculations the following screen will appear:

```
      ALPHA is equal to .0351563
       reject your null hypothesis if
'T' is greater than or equal to  7
      TO CONTINUE - STRIKE ANY KEY
```

This screen would have appeared slightly different if we had chosen a lower tailed test or a two tailed test. After striking any key, The M100 will inquire whether you wish to determine what your *ALPHA HAT* value is.

```
    Do you wish to find your actual
          ALPHA HAT VALUE?

Just input 'Y' for Yes or 'N' for No
```

The M100 will only accept a Capital *"Y"* or a Capital *"N"*. Any other entry will cause the computer to remain in the loop waiting. If the computer does not immediately respond, check to see that you have "Caps Lock" on. *DO NOT STRIKE THE ENTRY KEY AFTER INPUTING THE LETTER OR THE COMPUTER WILL SKIP A SCREEN DISPLAY.* In the case of our example problem we will input a "Y".

```
Please input your observed 'T'?  7
```

The value to input for "'T'" is the number of observed "Pluses". We observed "7" cases, so this is the number we input.

The computer responds with the following.

```
ALPHA HAT is equal to .0351563
TO CONTINUE - STRIKE ANY KEY
```

This means that by chance, seven or more Pluses would occur with a probability of .0351563 under a true null hypothesis.

We have completed the Sign Test/Cox-Stuart Test. Strike any key and the following screen appears.

```
Strike 'C' to do another test
If you are finished strike any other key
```

If you strike "C", the machine resets itself to the Module Main Menu. The input of any other key prepares the machine to receive either the typed entry "Menu", or the input of "f8" function key to return to the M100 main menu.

d. Cox-Stuart Test

General

The Cox-Stuart test is very similar to the sign test. It also is based on a binomial test with a **P^* equal to 1/2**. The major difference lies in the fact that the Cox-Stuart test is used either as a test for trends, or as an ordinal level test of correlation on a single sample.

Example Problem

Problem Setting

Let us assume that you have a sample of 20 people of various ages. We believe that as people become older, they tend to become less flexible, or more set in their ways. To test this you develop and administer a psychological profile battery to determine the degree of flexiblity of these 20 people. The scores you derived are as follows:

CASE	AGE	SCORE
1	26	3
2	27	6
3	34	3
4	35	2
5	39	4
6	41	2
7	42	7
8	42	2
9	45	9
10	53	4
11	54	6
12	54	5
13	57	8
14	58	7
15	61	6
16	61	5
17	65	3
18	71	9
19	73	6
20	74	2

We divide these sample scores into two halves. In this manner, we form (X_i, X_{i+c}) pairs. These are now treated the same as the (X,Y) pairs were in the sign test. A "Plus" is assigned when the X score is lower than the Y score, and a "Minus" is assigned when the X score is higher than the Y score in the pair.

PAIR	(Younger) X SCORE	(Older) Y SCORE	Associated Sign
1,11	3	6	+
2,12	6	5	-
3,13	3	8	+
4,14	2	7	+
5,15	4	6	+
6,16	2	5	+
7,17	7	3	-
8,18	2	9	+
9,19	9	6	-
10,20	4	2	-

You are interested in determining if our inital hypothesis is true. Stated formally, the hypothesis would be as follows:

$$H_{0:}\ P(+) \leq P(-)$$
$$H_{1:}\ P(+) > P(-)$$

Computer Solution to Problem

We have ordinal level data and we are looking for a trend; therefore we select "3" from the Module Main Menu. (Note that it is not necessary to strike the "enter" key after selecting your test.)

```
                    MENU

   1-Binomial Test      2-Quantile Test
   3-Cox-Stuart Test    4-Quantile C.I.
              5-Sign Test

    PLEASE MAKE YOUR SELECTION <1-5> 3
```

The M100 now asks you if you wish to check our assumptions.

```
Do you wish to check the assumptions
of the test that you have selected?

Just input 'Y' for yes or 'N' for no
```

If you wish to check the assumptions, simply enter a Capital *"Y"* otherwise you must enter a Capital *"N"*. (*The machine will remain in the loop until one of these two letters is input.*) If you input an "N" for your response, the M100 will skip the data assumption routine and request your input parameters. For the purposes of this example we will assume that our answer was "Y" to the request for information on the test assumptions. The following screen will appear:

```
      You selected the Cox-Stuart Test
       this test assumes you meet the
          following assumptions

       TO CONTINUE - STRIKE ANY KEY
```

At this time you may strike any key except the function keys located above the keyboard, the shift keys, or the control keys in order to continue.

The following screen listing the assumptions of the sign test will now appear.

```
1-Ordinal or Higher Level Data
2-All Observations are IID

TO CONTINUE - STRIKE ANY KEY
If you fail the assumptions then
to return to the menu input 'M'
```

The flexibility scale you developed is certainly ordinal, and the data points are independent and identically distributed. It would therefore appear that we meet the assumptions of the test. You continue by "striking a key".

The machine will now query you for the parameters needed to perform the test. In the sign test, you are interested in the number of times *"X is Less than Y"* and *"X is Greater than Y"*. In this example, we classified the younger person as X, and the older as Y. This classification was arbitrary. If the classification were reversed, the choice of a tail location on a one tailed test would have to be switched. If we had had ties where *"X is equal to Y"* these would have been omitted.

```
Input the # of times X<Y (+)  6
```

We input a "6" here because there were six cases that younger person's flexibility scores were lower than the older person's score.

The next screen appears which requests the information concerning the reverse situation.

```
Input the # of times X>Y (-)  4
```

We input an "4" and strike the "enter" key to continue.

Now the M100 will request input from you concerning the significance level or *Alpha Level* at which you wish to test your null hypothesis. It will accept any decimal value between 0 and 1 for alpha.

```
Please input the ALPHA VAlUE .10
```

The Binomial Distribution is discrete, and the machine has been programmed to ensure that your actual alpha will always be "equal to or less than" the alpha value which you input. We input .10 for our example.

The final input request concerns the location of your critical regions. This screen requests you input an integer indicating where you want the critical region located. You can chose a two tailed test or a one tailed test. *As with the Sign test discussed above, this step should be performed carefully*, as the assignment of X and Y directly influence the location of the critical region. The tail that we wish to examine is the *"Upper Tailed Test"* because we want to place our original conjecture on trial.

```
Please select your critical region
1 - Two Tailed Test
2 - Lower Tail Only
3 - Upper Tail Only
PLEASE MAKE YOUR SELECTION <1-3>? 3
```

We input a "3" for the upper tailed test.

The next screen is self explanatory.

```
I'm Calculating
```

Upon completion of the calculations the following screen will appear:

```
ALPHA is equal to .0546875
 reject your null hypothesis if
'T' is greater than or equal to  8
TO CONTINUE - STRIKE ANY KEY
```

This screen would have appeared slightly different if we had chosen a lower tailed test or a two tailed test. After striking any key, The M100 will inquire whether you wish to determine what your *ALPHA HAT* value is.

```
Do you wish to find your actual
       ALPHA HAT VALUE?

Just input 'Y' for Yes or 'N' for No
```

The M100 will only accept a Capital "*Y*" or a Capital "*N*". Any other entry will cause the computer to remain in the loop waiting. If the computer does not immediately respond, check to see that you have "Caps Lock" on. *DO NOT STRIKE THE ENTRY KEY AFTER INPUTING THE LETTER OR THE COMPUTER WILL SKIP A SCREEN DISPLAY.* In the case of our example problem we will input a "Y".

```
Please input your observed 'T'?  6
```

The value to input for "'T'" is the number of observed "Pluses". We observed "6" cases, so this is the number we input.

The computer responds with the following.

```
ALPHA HAT is equal to .3769533
TO CONTINUE - STRIKE ANY KEY
```

This means that by chance, six or more Pluses would occur with a probability of .376953 under a true null hypothesis. This outcome does not indicate a trend to become less flexible as one becomes older, so we would retain our null hypothesis.

We have completed the Cox-Stuart Test. Strike anv key and the follov·ing screen appears.

```
Strike 'C' to do another test
If you are finished strike any other key
```

If you strike "C", the machine resets itself to the Module Main Menu. The input of any other key prepares the machine to receive either the typed entry "Menu", or the input of "f8" function key to return to the M100 main menu.

|e. |Quantile Confidence Interval

General

The Quantile Confidence Interval test is an application of the binomial test to an ordinal level, discrete random variable. The test permits you to determine a confidence interval equal *"1 - Alpha"*.

* * *Example Problem* * *

Problem Setting

Recall that, in the Quantile Test example, we had data on Army Physical Fitness Tests from three military posts. We were given the combined median scores on each of the three events. These median scores were 15.6 minutes for the 2 mile run, 43 pushups, and 51 situps. We tested a Special Forces unit's pushup scores to determine if they were really better than the "Army Average" soldier. Now you have been directed by your commander to examine the scores of one specific 28 man platoon. This platoon has been identified as seeming to have substandard performance. The commander tells you that the statistical findings will be sent to higher headquarters and will be the determining factor in whether or not the noncommissioned officer in charge is permitted to remain in the Army. The commander would therefore like to be at least 95% confident that this is not a chance occurrence. The scores on the pushups for this platoon are as follows:

34 36 36 37 37 37 38 38 39 39 39 40 41 41

42 43 43 43 45 45 46 48 49 52 58 60 60 62

Computer Solution to the Problem

It seems appropriate, based on the directions from your boss, to calculate a Quantile Confidence Interval. So we chose selection "4" from the Module Main Menu.

```
                         MENU

        1-Binomial Test       2-Quantile Test
        3-Cox-Stuart Test     4-Quantile C.I.
                    5-Sign Test

        PLEASE MAKE YOUR SELECTION <1-5> 4
```

(*Note that it is not necessary to strike the "enter" key after selecting the test you wish to perform.*) The following screen appears:

```
    Do you wish to check the assumptions
    of the test that you have selected?

    Just input 'Y' for yes or 'N' for no
```

For the example, we will check the assumptions of the Quantile Confidence Interval. by inputing a Capital "*Y*". If you have already performed the Quantile Test you would probably input a *Capital "N", because the assumptions are identical for both tests*, and you are using the same type of data. This "N" input would causes the M100 to skip the data assumption routine and request your input parameters. If you input "Y" the M100 provides the following two screens:

```
          You selected the Quantile Test/CI
           this test assumes you meet the
               following assumptions

           TO CONTINUE - STRIKE ANY KEY
```

```
    1-Ordinal or Higher Level Data
    2-All Observations Are IID

    TO CONTINUE - STRIKE ANY KEY
    If you fail the assumptions then
    to return to the menu input 'M'
```

If you fail any of the assumptions, then you should input an *M* to return to the Main Menu. In this example, we meet the requirements for a Quantile Confidence Interval Test. So we strike a key proceed with our test.

The program now requests the four parameters necessary to perform the Confidence Interval calculations. The first is *N*.

```
Please input N? 28
```

We know we are interested in a 28 man platoon so we input that number.

The next screen requests that you input a decimal value between 0 and 1 for the P^* (hypothesized probability). We were only given information on the "Median" scores, so we will use ".5 " for our probability.

```
Please input P(robability) .50
```

We strike the "enter" key and continue.

The M100 will now ask you for information concerning the significance level or *Alpha Level*. The program will accept any decimal values between 0 and 1 for Alpha. Due to the discrete nature of the Binomial Distribution and the machine program, your actual alpha will be "equal to or less than" the alpha value which you input. We arbitrarily select an alpha of .05 for this example. This gives us a ≥ 95% confidence interval.

```
Please input the ALPHA VAlUE .05
```

The final request for parameters concerns the location of the critical regions. You can chose a two tailed or a one tailed confidence interval. We believe that the commander is not concerned with overachievers. So we decide to conduct a *"Lower Tailed Test"*, and select "2".

```
Please select your critical region
        1 - Two Tailed Test
        2 - Lower Tail Only
        3 - Upper Tail Only

PLEASE MAKE YOUR SELECTION <1-3>? 2
```

We strike the "enter" key and continue.

While the calculations are in progress, the screen will display:

```
I'm Calculating
```

Upon completion of the calculations the following screen will appear:

```
 The extreme tail values are presented
below.  You will need to select the N's
 which will determine the calculation
          of your total ALPHA.

       TO CONTINUE - STRIKE ANY KEY
```

The next screen presents you with the actual CDF values for three observations. The observation which is closest to the requested alpha value you input earlier and and its' respective CDF value is presented as the middle case. Here we had input alpha equal to ".05", and the closest alpha value in the discrete binomial distribution occurs at the 9th observation and has a value of .0435793. The next smaller and the next larger CDF values are also presented. We chose this method of presentation to permit you to decide if you wished to use an alpha value which was slightly higher or slightly larger than that which you had originally selected. In this case, .0435793 is close to .05, so we select "9" as our N value, and strike the "enter" key.

```
            OBS#      LOWER CDF
             8         .0178491
             9         .0435793
             10        .0924667

  Input the N for the lower OBS# 9
```

If you had selected an upper tailed confidence interval, the observation numbers would have been associated with their respective *"1 - CDF"* value and you would have selected an "upper" observation number. The two tailed confidence interval presents both the upper and lower observations associated with their *"CDF"* and *"1 - CDF"* values. In that case, you would select an upper and a lower observation number. Your actual alpha value would be the sum of the two associated values.

The next screen appears with the data we need to assist the commander.

```
ALPHA is equal to .0435793

'T1' lower C.I. is < or = 10
TO CONTINUE - STRIKE ANY KEY
```

This is the information you need. This screen indicates that if you have 10 or fewer scores that are *"equal to or less than X^*"*, where X^* is the hypothesized median, then you cannot reject that X^* may be the true median. In our example, there are 18 scores which are less than or equal to "43". This too extreme a number to have occurred by chance, if the median of the sample data was really "43". You should inform the boss that this platoon is does not appear to be as physically fit as the "Army Average", and that he can be more than .95% confident that the median of the sample is less than "43". (If this had been a two tailed interval, you would have had a screen appear which asked if you wanted the machine to determine the value of the data points associated with the ""T1"" and the ""T2"" values. An answer of yes means that the M100 will ask for you to input all your scores.)

We have completed the Quantile Confidence Interval Test. We strike a key and the following screen appears:

```
        Strike 'C' to do another test
    If you are finished strike any other key
```

If you strike "C", the machine resets itself to the Module Main Menu. The input of any other key prepares the machine to receive either the typed entry "Menu", or the input of "f8" function key to return to the M100 main menu.

3. TESTS BASED ON THE CHI SQUARE DISTRIBUTION

In the "CHISQ" module are the Cochran test, median test, chi square test, McNemar ($N \geq 20$), chi square goodness of fit test, and tolerance limits. These tests are all derived from the chi square distribution, which is a sum of "N" independent standard normal variables, squared [Ref. 6]. The degrees of freedom associated with the chi square test, are a function of the number of squared variables. When the degrees of freedom equal one, the square root of the chi square statistic is identical to the Z score for a normal(0,1).

This module is designed so that when ALPHA is requested, it must be input as a decimal value. The CHISQ module also limits the Chi Square, McNemar, and the Median test to contingency tables that are no greater than 14 rows by 14 columns. To use a larger table, see APPENDIX C of this paper for instructions on redimensioning the arrays.

If you wish to exit this program when in progress, strike "shift" and keep this key depressed while striking the "break/pause" button above the keyboard, or strike the "control" key and "C". If you wish at that point to exit to the M100 main menu, you need only strike the "f8" function key. If you strike the "f4" function key, the program will reinitialize and run another test.

Once you enter the "CHISQ" module and the program has initialized, the Module Main Menu will appear on the screen as follows:

```
                    MENU

1-Tolerance Limits   2-McNemar Test
3-Cochran Test       4-Median Test
5-Chi Square Test    6-Goodness of fit

     PLEASE MAKE YOUR SELECTION <1-6>
```

Each procedure in the module is demonstrated as a "self contained - stand alone" example, so that you may study and use them in any order you like. After you have worked through several of the tests within the module, you may find that some of the procedural information and screen explanations are redundant.

a. Tolerance Limits

General

Tolerance limits provide an interval within which we can be at least *"1-alpha"* confident that at least a proportion of the population equal to *"q"* is within the interval [Ref. 2:p.117]. One common use of tolerance limits is to determine the sample "N" needed to ensure that the above criteria are met. Although the test makes no assumptions about the underlying distribution, it does assume either that there is an infinite population from which the sample is drawn, or that sampling is done with replacement.

** * Example Problem * **

Problem Setting

Suppose you work in a section that tests expendable military equipment. Your job requires that you determine how large an "N" should be selected out of equipment lots in order to be confident that the manufacturer is providing equipment which meets the contract specifications. The most recent item with which you are concerned is that of nylon helicopter cargo slings. The contractor guarantees that with 95% reliability these slings will meet their specified load rating. Your boss wants to be "confident" that this is so. You determine that this means your boss, who is not a trained operations analyst, would probably accept an "ALPHA" value or Type I error of ".05".

.Computer Solution to the Problem

We wish to establish the size of the sample required to ensure that at least a certain percentage lies within a certain confidence interval. Therefore we will select "1" from the Module Main Menu. (*Note - it is not necessary to strike the "enter" key after making your selection.*)

```
                          MENU

   1-Tolerance Limits    2-McNemar Test
   3-Cochran Test        4-Median Test
   5-Chi Square Test     6-Goodness of fit

        PLEASE MAKE YOUR SELECTION <1-6> 1
```

The following screen will now appear:

```
    Do you wish to check the assumptions
    of the test that you have selected?

    Just input 'Y' for yes or 'N' for no
```

If you wish to check the assumptions, simply enter a Capital "*Y*" otherwise a Capital "*N*" will cause the machine to skip the data assumption loop. Be certain that you have "*CAPS LOCK*" on when you select the letter otherwise the M100 will remain in the loop indefinitely. We will assume that you answer an *"Y"* to the request for information on the test assumptions. The following screen will appear:

```
You selected the Tolerance Limits
this test assumes you meet the
following assumptions

TO CONTINUE - STRIKE ANY KEY
```

You may strike any key except function keys, shift keys, or control keys to continue.

The following screen now will appear:

```
1-The X's are a random sample
2-Ordinal level data

TO CONTINUE - STRIKE ANY KEY
If you fail the assumptions then
to return to the menu input 'M'
```

If you decide that you do not meet the assumptions of the test then input an *"M"*. This returns you to the Module Main Menu, from which you may select another test. For our example, we decide that we have chosen the correct test, and "strike any key" to continue.

The program is now ready for the test parameters. To calculate tolerance limits, we must input four parameters. These are designated as *"q"*, *"r"*, *"m"*, and *"1 - alpha"*. The first parameter requested is the confidence interval, *"1-alpha"*.

```
What Confidence Interval do you want?
      (.90,.95,Your Choice)?  .90
```

We had decided after talking to the boss, that an alpha of ".10" was appropriate, so we input ".90 " and strike the "enter" key. After the machine has accepted the first parameter, it will return with the following screen display requesting that you input the desired "population proportion".

```
What is the population proportion?
        (Q Value)?  .95
```

We input as the proportion of the population the value stated in the contract specifications. His contract states that 95% of his straps will meet or exceed the rated load capacity, therefore we input ".95".

The machine will now require information from you concerning the values for "*R*", and "*M*". If either one of these values is equal to zero, then the tolerance limit is one sided. (R = 0, means the limit is only upper bounded, while an M = 0 is lower bounded.) The most commonly used values for R and M are 1, and that is what we will use in this example. (*Note - The sum of R and M must be at least equal to "1" or you will remain in the loop.*)

```
What value for 'R' 1
```

```
What value for 'R' 1
What value for 'M' 1
```

While the inverse chi square distribution is being calculated, the following self explanatory screens are displayed.

```
I'm Calculating
```

```
Still going
```

```
Still Going
I'm nearly finished
```

```
Still going
The last loop to do
```

Upon completi. a of the calculations, the screen will return with following output data.

```
To be .90  confident you need
an N > or = to  76.3671875

TO CONTINUE - STRIKE ANY KEY
```

From this outcome, we can inform our boss that in order to be 90% confidence that 95% of the contractors' straps are indeed exceeding the load specification, in a given lot.

You have now completed the Tolerance limit. We strike a key and the following screen appears:

```
Strike 'C' to do another test
If you are finished strike any other key
```

If you strike "C", the machine will reinitialize itself. Striking any other key followed by the "f8" function key returns you to the M100 main menu. Do not strike the "enter" key after making your selection.

b. Cochran Test

General

The Cochran test for related observations is an attempt to apply the power of the analysis of variance design to nominal level data. The test layout is structured with the treatments across the columns, and the persons or blocks down the rows. The treatment outcomes are dichotomous, with outcomes only indicated as *"1"* or *"0"*. Each block receives every treatment, so this is a randomized complete block design. If there are only two treatments, this test reduces to the McNemar test.

* **Example Problem** *

Problem Setting

There are three new medications for sea sickness which you have been asked to test in order to determine which, if any, should be stocked on board Navy vessels. On one aircraft carrier you randomly select 15 sailors out of all on board who have a history of sea sickness. You further subdivide these 15 into 3 subgroups, and decide that each time there is a storm, one of the three groups will receive one of the drugs, until each group has been administered all three drugs. This design is to overcome the influence of storm intensity. If drugs work, and the sea sickness abates, then they receive a *"1"* otherwise they received a *"0"*. After the first three storms, you have the following data:

SAILOR	MEDICINE USED A	B	C	Totals
1	1	1	0	2
2	0	1	1	2
3	1	1	1	3
4	0	1	1	2
5	0	0	1	1
6	1	1	0	2
7	1	1	0	2
8	0	0	0	0
9	1	1	1	3
10	0	1	0	1
11	1	0	0	1
12	1	0	0	1
13	0	1	1	2
14	0	1	1	2
15	1	1	1	3
Totals	8	11	8	

Let's determine if there is any statistically significant differences between the three medications.

Computer Solution to Problem

We collected nominal level, dichotomized treatment data on our randomly selected blocks, the sailors; therefore, we will select "3" from the Module Main Menu. (*Note that it is not necessary to strike the "enter" key after selecting your test.*)

```
                         MENU

   1-Tolerance Limits    2-McNemar Test
   3-Cochran Test        4-Median Test
   5-Chi Square Test     6-Goodness of fit

        PLEASE MAKE YOUR SELECTION <1-6> 3
```

The following screen will now appear:

```
Do you wish to check the assumptions
of the test that you have selected?

Just input 'Y' for yes or 'N' for no
```

We answer with a Capital *"Y"* to the request for information on the test assumptions. A Capital *"N"* would have caused the machine to skip the data assumption loop. The following screen will appear:

```
You selected the Cochran Test
this test assumes you meet the
following assumptions

TO CONTINUE - STRIKE ANY KEY
```

We strike any key to continue.

The following screen now will appear:

```
1-Randomly selected treatment blocks
2-Dichotomous treatment outcomes (0,1)

TO CONTINUE - STRIKE ANY KEY
If you fail the assumptions then
to return to the menu input 'M'
```

The data we have collected seems to meet the assumptions of the test so we "strike any key" and begin to input the data necessary for the calculations. If you make an error in the selection of the test, or fail to meet the assumptions, input an *"M"* to return to the Module Main Menu.

First, the program requests information on the number of columns or treatments. In our example, three different drugs were administered, so we input a *"3"*.

```
How many columns do you have?  3
```

After striking the "enter" key, the M100 begins a loop requesting that you input the column totals. The loop will execute three times for our example.

```
Input the column  1  total? 8
```

We input 8, as the column "1" total, 11 as the column "2" total, and finally 8, as the column "3" total.

The machine now asks about the number of "blocks" that we have in the design. We had 15 sailors, which we randomly selected from the population of sailors who suffer from sea sickness. (*Note - there are no size limitations on the number of rows or the number of columns that you may have for this test, except those due to the M100 memory size.*)

```
How many rows do you have?  15
```

The M100 now enters the input loop for the row totals. For our example data we input fifteen different row totals, one by one, as the following prompt appears 15 times successively.

```
Input the row  1  total?  2
```

When the last row total is input, the M100 will calculate the Cochran test statistic. The following self explanatory screen will appear while the calculations are in progress.

```
I'm Calculating
```

When completed the following screen will appear:

```
Your test statistic is
equal to   1.63636
your 'Alpha Hat' is .441233
TO CONTINUE - STRIKE ANY KEY
```

Our data produced a *"test statistic"* of 1.63636, with two degrees of freedom (C-1). The small number of degress of freedom cause *"Alpha Hat"* to be extremely large. We therefore cannot say that there is any difference, statistically, between the three medications we tested. We might recommend to the boss to try other medicines, to stock the cheapest one, or take "B" since numerically it did perform better.

This concludes the Cochran test. We strike a key and the following screen appears:

```
Strike 'C' to do another test
If you are finished strike any other key
```

If you wish to perform another test, strike *"C"* and the machine will reinitialize itself. If you do not wish to continue, then strike another key, and followed by the *"f8"* key to return to the M100 main menu. You need not strike the "enter" key after making your selection.

c. Median Test

General

The median test is used to test whether "n" independent samples have different medians, or central tendencies indicators. It is really a special application of the chi square test with the row marginals fixed by the value of the *"grand"* median. (Note - You can extend this test to examine other quantiles by simply changing the criteria for the rows.) [Ref. 2:p. 174].

* **Example Problem* * *

Problem Setting

Let us assume that the Army is procuring 155mm howitzer shells from three different manufacturers. It has been observed when units are firing for qualification that their CEP (Circular Error Probable) is not systematic. You have been assigned to investigate this problem. You believe that it is possible that the shells from the manufacturers are are not all within the same degree of error tolerance. You collect data on the next 1000 rounds fired at the range, directing that the units be issued rounds from only one manufacturer on each of the three days they do qualification firing. In this way you will attempt to control for the possiblity the CEP error is due to unit performance.

Using all 1000 rounds, you determine the *"grand"* median CEP is 95 meters. You break out the projectiles by manufacturer, and the data looks as follows:

	MANUFACTURER			Totals
	A	B	C	
>95	287	105	108	500
<=95	47	227	226	500
Totals	334	332	334	

Computer Solution to Problem

The measurement of CEP errors in the field is not extremely precise, so we will only consider this data to be ordinal. We are interested in testing if the CEP for the different manufacturers projectiles are the same. From the Module Main Menu we select "4". (*Note that it is not necessary to strike the "enter" key after selecting your test.*)

```
                    MENU
1-Tolerance Limits    2-McNemar Test
3-Cochran Test        4-Median Test
5-Chi Square Test     6-Goodness of fit
     PLEASE MAKE YOUR SELECTION <1-6> 4
```

The following screen will now appear:

```
Do you wish to check the assumptions
of the test that you have selected?
Just input 'Y' for yes or 'N' for no
```

We will check our assumptions in this example problem, so we input a *"Y"* to the request for information on the test assumptions. The next two screens will appear:

```
You selected the Median Test
this test assumes you meet the
following assumptions

TO CONTINUE - STRIKE ANY KEY
```

```
1-Independent random samples
2-At least ordinal level data

TO CONTINUE - STRIKE ANY KEY
If you fail the assumptions then
to return to the menu input 'M'
```

We believe that we have data which meets the above assumptions; therefore, we strike any key and continue. If you discover that you fail to meet the assumptions, input an *"M"*.

In order to perform the calculations, the M100 requires that you input the number of rows and columns in the contingency table. We will input a *"2"* for the number of rows and *"3"* for the number of columns, since we had three munitions manufacturers, striking the "enter" key after both inputs. (*Note - the median test will only accept "2" rows as an input, and these must be input so that the* ***"above the median scores"*** *are placed in the first row.*)

```
Please enter the number of rows in
the contingency table?  2
Now enter the number of columns? 3
```

The M100 now begins a loop requesting that you input the cell frequencies begining with the first row first column, and working across the columns.

```
Input the number in the cell in

        ROW-  1
        COLUMN-  1

    THE NUMBER ? 287
```

We input the numbers 287, 105, 108, for the first row, and 47, 227, 226 for the second row. In the example, we selected the 2 row totals were exactly equal. If they had not been equal, the M100 would have queried you to determine if you have made an error. If you have not, simply input "N" and continue, otherwise you have another opportunity to input the data. After the last number is entered, the following screen will appear.

```
I'm Calculating
```

When the calculations are finished, the M100 will return the following screen displaying the test results.

```
Your test statistic is
 equal to   258.975
your 'Alpha Hat' is  0

TO CONTINUE - STRIKE ANY KEY
```

Here our observed *"test statistic"* was so large that the *"Alpha Hat"* was smaller than .00001, and has been rounded to zero. We can say that there is statistical difference between the rounds manufactured by the three different companies.

This concludes the Median test. We strike a key and the following screen appears:

```
Strike 'C' to do another test
If you are finished strike any other key
```

The machine will reinitialize itself if you strike "*C*". If you do not wish to perform another test then strike any key, and then the "*f8*" key. This returns you to the M100 main menu. You need not strike the "enter" key after making your selection.

d. Chi Square Test for Differences in Probabilities

General

The Chi Square test is used to determine if the the probability of discrete categories of occurrences are the same in several populations. It is also used is to test if several independent samples can be assumed to have come from the same population. Although this test is used very frequently, it is not recommended in situations where the data is clearly interval level, and the assumptions of the F test are satisfied.

* **Example Problem* * *

Problem Setting

Suppose that you work for the Army recruiting command at a recruiting station located in a metropolitan area. There are four high schools located in the community: a private high school, two public high schools, and a technical trade school. In the past, you have had the recruiters present the same speech at all the high schools in an attempt to convince the students to enlist upon graduation. The effects of the "dog and pony show" on enlistments does not seem to have been the same in all the high schools. You believe that perhaps the speech should be varied depending on the type of recruits you can expect to get from each school. You have records on all the enlistments from this recruiting station for the last two years and these records include the high school from which the enlistee graduated. You would like to determine if the enlistment profiles by MOS (military occupation status) vary by high school. You decide to divide the jobs into three major areas, combat arms (infantry, armor, etc.), combat support arms (engineers, maintenance, military police, etc.), and service support arms (finance, legal, medical, etc.) and to take a random sample of all the local enlistments. Your null hypothesis is that there is no difference between the high school enlistment profiles.

	MILITARY SPECIALITIES		
SCHOOL TYPE	Combat	Combat Support	Service Support
Private	7	14	22
Public (1)	18	9	6
Public (2)	21	11	8
Technical	8	23	11

Let's solve this problem using the M100.

Computer Solution to Problem

We have frequency count data from three independent samples, therefore we are limited (assuming we do not violate any test assumptions) to nominal tests for "k" independent samples. Since we do not have a treatment/block design needed to perform a Cochran test, it would seem that the most appropriate test on this module is the Chi Square test. We select "5" from the Module Main Menu. (*Note that it is not necessary to strike the "enter" key after selecting your test*).

```
                         MENU

  1-Tolerance Limits    2-McNemar Test
  3-Cochran Test        4-Median Test
  5-Chi Square Test     6-Goodness of fit

       PLEASE MAKE YOUR SELECTION <1-6> 5
```

The following screen will now appear:

```
    Do you wish to check the assumptions
    of the test that you have selected?

    Just input 'Y' for yes or 'N' for no
```

We believe that we meet all the assumptions, but we will check the assumptions to ensure that we have not overlooked any. We input a Capital *"Y"* to the request for this information. If you want to skip the loop for the assumptions, then a Capital *"N"* would have been the appropriate response. Since we input a *"Y"* the following two screens will appear:

```
You selected the Chi Square test

this test assumes you meet the
following assumptions

TO CONTINUE - STRIKE ANY KEY
```

```
1-Independent random samples
2-Each observation is classified into
   only one row and one column

   TO CONTINUE - STRIKE ANY KEY
   If you fail the assumptions then
   to return to the menu input 'M'
```

We know that we have random samples, and that a recruit could have graduated from only one of the high schools in question. We strike key and continue. If you discover that you fail to meet the assumptions, input an *"M"*. This input returns you to the Module Main Menu.

The calculations require that you input the number of rows and columns in the contingency table. We will input a *"4"* for the number of high schools shown in the rows and *"3"* for the military specialties shown in the columns, striking the "enter" key after each input.

```
Please enter the number of rows in
     the contingency table?  4
Now enter the number of columns? 3
```

The M100 now begins a loop requesting that you input the cell frequencies begining with the first row, first column and working across the columns.

```
Input the number in the cell in
          ROW-   1
          COLUMN-   1
     THE NUMBER ? 7
```

We input all the data as it is laid out in the *"problem setting"* portion of this discussion. When the last row and column data has been input, the following screen will appear:

```
I'm Calculating
```

The machine will calculate the test statistic from the data, and when it has finished it will return the following screen displaying the results for the problem data input.

```
      Your test statistic is
        equal to     30.0849
   your 'Alpha Hat' is  3.8E-05
   TO CONTINUE - STRIKE ANY KEY
```

With these results, we should reject our null hypothesis. It would appear in this case, that there does seem to be a difference in the enlistment profiles of these high schools. The recruiters might find their time more wisely invested if they spoke about combat arms opportunities at some schools, and combat support arms or service support arms opportunities at others.

This concludes the Chi Square test. We strike a key and the following screen appears:

```
Strike 'C' to do another test
If you are finished strike any other key
```

If you wish to perform another test strike *"C"* and the machine will reinitialize itself. To return to the M100 main menu strike any key, and followed by the *"f8"* key. You need not strike the "enter" key after making your selection.

e. McNemar Test

General

The McNemar test evaluates independent, bivariate, nominal level, random variables from related samples in order to determine if we can ". . .detect a difference between the probability of (0,1) and probability of (1,0)" [Ref. 2:p. 130]. Most *frequently this test* is used to determine the significance of an intervening variable. For example, when we take a before and after sample, we are attempting to determine if some event between the two sample measurements had any significant impact. (Note - even though we obtain significance we must attempt to ascertain if the intervening variable measured is really the correct one.)

* **Example Problem** *

Problem Setting

Assume that you are the training officer of a basic training unit. You have received some films which are reported to be effective in changing attitudes about drugs. You view these films, and feel that the drug users in the films are slightly glamorized. You believe that this might make these films less effective on moderating drug use. You decide to test your belief by taking a group of viewers "before" the film and asking them questions about drug use. After the film series, you ask the same questions to all those in the original group who viewed the entire series. The results on one such question are as follows:

Would you use marihuana?

	(AFTER FILMS) Yes	No
(BEFORE FILMS)		
Yes	18	12
No	8	15

Let's test our original premise by conjecturing that there will be no significant difference in the (0,1) and (1,0) shifts.

Computer Solution to Problem

We have related samples with a dichotomous response to a question. The level of our data is nominal, therefore it would seem that the most appropriate test on this module is the McNemar test. We select "2" from the Module Main Menu. (*Note that it is not necessary to strike the "enter" key after selecting your test.*)

```
                         MENU
 1-Tolerance Limits   2-McNemar Test
 3-Cochran Test       4-Median Test
 5-Chi Square Test    6-Goodness of fit

      PLEASE MAKE YOUR SELECTION <1-6> 2
```

The following screen will now appear:

```
  Do you wish to check the assumptions
  of the test that you have selected?

  Just input 'Y' for yes or 'N' for no
```

We will check the assumptions. We input a Capital *"Y"* to the request for this information. If you want to skip the loop for the assumptions, then a Capital *"N"* would have been the appropriate response. Since we input a *"Y"*, the following three screens will appear:

```
You selected the McNemar test

this test assumes you meet the
following assumptions

TO CONTINUE - STRIKE ANY KEY
```

```
1-'N' equal or greater than 20
2-The pairs (X,Y) are mutually
   independent
3-Nominal level data in two categories

TO CONTINUE - STRIKE ANY KEY
```

(*Note - the McNemar test which uses a smaller "n" is not calculated here.*)

```
If you fail the assumptions then
to return to the menu input 'M'
```

We know that the set of *"X"* responses (before) and *"Y"* responses (after) are independent nominal level responses, and that "N" *is greater than twenty.* We have, therefore, met the assumptions and strike any key and continue. If you discover that you fail to meet the assumptions, input an *"M"*. This input returns you to the Module Main Menu.

The M100 now begins a loop requesting that you input the four cell frequencies begining with the first row, first column and working across the columns.

```
Input the number in the cell in

          ROW-   1
          COLUMN-   1

     THE NUMBER ? 18
```

We input the four cell frequencies shown in the *"problem setting"* portion of this discussion. When the last row and column data has been input, the following screen will appear:

```
I'm Calculating
```

The machine will calculate the test statistic from the data, and when it has finished it will return the following screen displaying the results for the problem data input.

```
Your test statistic is
equal to   .8
your 'Alpha Hat' is  .371093
TO CONTINUE - STRIKE ANY KEY
```

From the results of the data you should retain your null hypothesis. However, even more importantly you should inform your boss that this film has an adverse effect on attitudes about drugs and should probably be discontinued.

This concludes the McNemar test. We strike a key and the following screen appears:

```
Strike 'C' to do another test
If you are finished strike any other key
```

If you wish to perform another test strike "C" and the machine will reinitialize itself. To return to the M100 main menu strike any key, and followed by the "/S" key. You need not strike the "enter" key after making your selection.

|f. |Goodness of Fit test

General

The Chi Square Goodness of Fit test allows a single sample to be compared with a theoretical distribution to determine whether the sample could have been drawn from this hypothesized population.

* **Example Problem* *

Problem Setting

Assume that as an analyst, you have conducted a survey. You are not certain of the underlying population distribution and want to use only nonparametric methods to analyze all the data. Your boss, however, would like you to use parametric tests. You decide to check your data for normally, since this is an underlying assumption for many parametric tests. You have the following results on the ages of your respondents:

17	18	18	18	18	19	19	19	19	20	20	20	20	21	23
24	25	26	28	29	30	30	34	37	39	40	42	47	48	50

We calculate the mean and the standard deviation for this set of ages. Our mean age is 27.3 years and the standard deviation is 10.2 years. Let's check to see if this set of data are consistent with a normal population.

Computer Solution to Problem

We wish to do a goodness of fit test, so we select "6" from the Module Main Menu. (*Note that it is not necessary to strike the "enter" key after selecting your test.*)

```
                    MENU

1-Tolerance Limits   2-McNemar Test
3-Cochran Test       4-Median Test
5-Chi Square Test    6-Goodness of fit

     PLEASE MAKE YOUR SELECTION <1-6> 6
```

The following screen will now appear:

```
Do you wish to check the assumptions
of the test that you have selected?

Just input 'Y' for yes or 'N' for no
```

We will check the assumptions. We input a Capital *"Y"* to the request for this information. If you want to skip the loop for the assumptions, then a Capital *"N"* would have been the appropriate response. Since we input a *"Y"* two screens will appear:

```
You have selected the Goodness of fit
this test assumes you meet the
following assumptions

TO CONTINUE - STRIKE ANY KEY
```

```
1-An independent random sample
2-Data level appropriate to
   the distribution selected

TO CONTINUE - STRIKE ANY KEY
If you fail the assumptions then
to return to the menu input 'M'
```

We drew a random sample when we administered our questionnaire, and our data on age is adequate to permit the calculation of the two parameters necessary for a normal distribution. We therefore believe that we meet the assumptions of the test. We strike any key and continue. If you discover that you fail to meet the assumptions, input an *"M"*. This input returns you to the Module Main Menu.

The M100 now requests that you indicate the theoretical distribution against which you wish to test your sample data.

```
Select your theoretical distribution

    1- Normal Distribution
    2- Uniform Distribution
    3- Poisson Distribution

PLEASE MAKE YOUR SELECTION <1-3>  1
```

We input a "1" as our choice, since we assumed a normal distribution. (Note - do not strike the "enter" key after making your selection.)

The M100 will now request information on the number of discrete categories into which you wish to break the data. (Note - this would also be required if you were performing a Poisson or a uniform goodness of fit test. The classes on the Poisson distribution are assumed to run from 0 to one less than the number of classes, because the Poisson runs from 0 to infinity. Therefore the M100 adjusts the number of classes you input to insure that this occurs. For this example, we chose to "discretize" the normal curve into 6 sections. How many are chosen is a matter of judgement on the part of the analyst.

```
Please input the number of classes?  6
```

We strike the "enter" key. The next screen appears requesting first a mean, and then, without the screen clearing, a variance. (For the Poisson distribution, the M100 requests that lambda be input, while for the uniform, this screen is skipped.) We may estimate these parameters from our data, or we may use known values for both or either. The effect of calculating both parameters from the sample data will be a loss of two degrees of freedom. In our example we estimated the parameters from the sample data.

```
Please input the mean of your
theoretical distribution? 27.3
Now enter the variance of the
theoretical distribution? 106.1
```

Based on the sample mean and the variance the program calculates the scores to be used as the class boundaries. (When you test for a Poisson or a uniform, this step simply requests the input of the number of cases in each classes.)

```
Input the # of observed data points
< or = 17.3357 ? 1
```

```
Input the # of observed data points that
are > 17.3357 and < or = 22.8678 ? 13
```

The number of scores falling in each of the classes are input. In our example, we input successively 1, 13, 4, 4, 2, and 6. When we strike the "enter" key after the last input the following screen appears requesting information of the parameters.

```
How many parameters did you estimate
(0, 1 OR 2)? 2
```

When the Poisson distribution is tested however, the M100 will ask if you estimated lambda. The estimation of this parameter will cause the loss of one degree of freedom.

The next self explanatory screen appears:

```
I'm Calculating
```

The machine will calculate the test statistic from the data, and when it has finished it will return the following screen displaying the results for the problem data input.

```
Your test statistic is
equal to   18.4
your 'Alpha Hat' is  3.64E-04

TO CONTINUE - STRIKE ANY KEY
```

From these results, you cannot perform parametric tests on the data which require the underlying assumption of normality.

This concludes the goodness of fit test. We strike a key and the following screen appears:

```
Strike 'C' to do another test
If you are finished strike any other key
```

If you wish to perform another test, strike "C" and the machine will reinitialize itself. To return to the M100 main menu strike any key, and followed by the "f8" key. You need not strike the "enter" key after making your selection.

APPENDIX C

MODIFYING PROGRAM MODULES

To redimension the arrays for the BINOM module change the dimensions of all the arrays listed in line 130, shown below.

```
130 DIM CDF!(30),D!(30),PDF!(30)
```

The line to be changed in the CHISQ module is line 20 shown below:

```
20 DIM X!(15,15),C!(15),R!(15),N(3),N!(3)
```

In this line you need not change all the arrays however, only the first three variables X!, C!, and R!.

APPENDIX D

POSSIBLE PROGRAMMING PROBLEMS

My keyboard entries are not accepted.

This usually is solved by checking to see that the **"Caps Lock"** key is depressed. If this does not help the problem you are attempting to input a parameter which is not within the bounds allowed. Check the sample problem in the user's manual.

When I try to run the program I get an "?OM Error".

This error will occur if you do not have adequate memory available to initialize the arrays. First, check to see that the "paste" buffer does not contain any information. If it is already empty, then it will be necessary to erase some programs. To do so, enter basic and type the following:

```
KILL "<program designation>" <enter>
```

I ran the program and it returned a "?BS error".

You will receive a bad subscript error if you exceed the dimensioned size of the arrays. If this occurs, then see the appendix on redimensioning arrays, or solve the problem by hand.

The M100 skipped a screen.

There are two possible causes of this. First, you struck the keyboard too hard when inputting a parameter. Second, you struck the <enter> key when it was not required.

I tried to copy the program into BASIC and got a "?DS error".

This usually indicates that there are carriage returns imbedded in program lines. These may be removed by scrolling through the program to find them, or using the program CROUTLNE from the M100 disk to remove them.

In doing tolerance limits, after I enter R and M it asks for them again.

The values of "R" and "M" are not correct. Only one of these values can be equal to zero, not both.

APPENDIX E

BINOMIAL DISTRIBUTION PROGRAM

```
100 CLS
120 DEFSNGA: DEFINTM: DEFINTN: DEFINTK: DEFINTT: DEFINTX
130 DIM CDF!(30),D!(30),PDF!(30)
140 S=1
160 GOSUB 10020     'THIS IS BINOMIAL MENU SUBROUTINE
180 CLS: PRINT: PRINTTAB(3) "Do you wish to check the assumptions"
185 PRINT: PRINT: PRINTTAB(3), "of the test that you have selected?"
190 PRINT@203, "Just input 'Y' for yes or 'N' for no";
200 B$=INKEY$: IF B$= "" GOTO 200
220 IF B$="Y" OR B$="y" GOTO 280
240 IF B$="N" OR B$="n" GOTO 1000
260 CLS: PRINT@125,"The response must be 'Y' or 'N'"
270 PRINT@174, "TRY AGAIN": GOTO 180
280 GOSUB 11000
1000 ON QT GOTO 2000,2100,2700,3200,2700
2000 '****     BINOMIAL TEST
2020 GOSUB 18000 'SUBROUTINE TO INPUT ALL PARAMETERS
2040 GOSUB 15800 ' PDF CALCULATIONS
2060 GOSUB 16080 ' ALPHA
2065 GOSUB 13020 ' INKEY
2070 GOTO 13200 'ALPHA HATS
2100 '****    QUANTILE TEST
2111 GOSUB 18000    'INPUT VARIABLES
2121 GOSUB 15800    'PDF CALCULATIONS
2131 GOSUB 16080    'ALPHA
2141 GOSUB 18740    'OUTCOME OUTPUTS
2151 ON T GOTO 2161,2161,2181
2161 PRINTTAB(2);"'T1' is less than or equal to ";LN
2171 IF T=2 THEN 2201
2181 IF UN+1>N THEN UN=UN-1
2191 PRINTTAB(2);"'T2' is greater than  ";UN
2201 GOSUB 13020
2211 GOTO 13200
2700 '*****    SIGN TEST/COX STUART
2720 ' PL=# OF (+)'S
2740 ' MI=# OF (-)'S
2780 ' N=SUM OF (+) AND (-)'S
2800 ' S IS A LOGICAL COUNTER FOR SIGN TEST
2820 CLS: PRINT@120,"  Input the # of times X<Y (+)";
2840 INPUT PL: CLS
2860 PRINT@120,"  Input the # of times X>Y  (-)";
2880 INPUT MI: CLS
2900 P=.5: S=1
2920 N=PL+MI
2940 GOSUB 15320 'INPUT ALPHA TOTAL
2960 GOSUB 15480 'INPUT TAIL VALUES
2980 S=T+1
3000 GOSUB 15800 'CALCULATES PDF,AND CDF
3020 GOSUB 16740 'ALPHA
3025 GOSUB 13020 'INKEY
3040 GOTO 13200 'ALPHA HATS
3200 '****     QUANTILE/CI
3220 GOSUB 18000 'THE INPUT VARIABLES
3240 GOSUB 15800 'PDF CALCULATIONS
3260 GOSUB 16080 'THE ALPHA
3300 CLS: PRINT: PRINT" The extreme tail values are presented"
3305 PRINT"below. You will need to select the N's"
3010 PRINT" which will determine the calculation"
3015 PRINT"          of your total ALPHA."
3320 PRINT: PRINTTAB(7);"TO CONTINUE-STRIKE ANY KEY"
```

```
3340 K$=INKEY$:IF K$ = ""GOTO 3340
3360 ON T GOTO 3380,3660,3740
3380 CLS
3385 PRINT"OBS#";TAB(5);"LOWER CDF";TAB(21);"OBS#";TAB(28);"UPPER 1-CDF"
3390 FOR X = 1 TO 3
3400 IF LN=0 THEN N1=(X-1) ELSE N1=(X-2)
3420 IF UN=N THEN N2=(X-3) ELSE N2=(X-2)
3430 ZZ = LN + N1
3440 PRINT ZZ;TAB(5);CDF!(ZZ+1);TAB(21);UN+N2;TAB(30);1-(CDF!(UN+N2+1))
3450 NEXTX
3460 PRINT:INPUT"   Input an N for lower OBS#";LN
3480 INPUT"   Input an N for upper OBS#";UN
3500 H1=CDF!(LN+1):H2=1-CDF!(UN+1):HT=H1+H2
3520 CLS:PRINTTAB(5);"ALPHA  is equal to";HT:PRINT
3540 IF T=3 GOTO 3600
3560 PRINTTAB(4);"'T1' lower C.I. is < or = ";LN+1
3565 IF UN+1 > N GOTO 3640
3580 IF T=2 THEN 3620
3600 PRINTTAB(4);"'T2' upper C.I. is > or = ";UN+1
3620 IF T=1 THEN 3820
3630 GOSUB 13020
3635 GOTO 13100
3640 UN=UN-1:GOTO 3600
3660 CLS:PRINTTAB(9);"OBS#";TAB(19);"LOWER CDF"
3680 FOR X=1 TO 3:IF LN=0 THEN N1=(X-1) ELSE N1=(X-2)
3700 PRINTTAB(9) LN+N1;TAB(19);CDF!(LN+N1+1):NEXTX
3720 PRINT:INPUT" Input the N for the lower OBS#";LN :HT=CDF!(LN+1)
3730 GOTO 3520
3740 CLS:PRINTTAB(9);"OBS#";TAB(19);"UPPER 1-CDF"
3760 FOR X=1 TO 3:IF UN=N THEN N2=(X-3) ELSE N2=(X-2)
3780 PRINTTAB(9) UN+N2;TAB(19);1-CDF!(UN+N2+1):NEXTX
3800 PRINT:INPUT " Input the N for the upper OBS#";UN
3810 HT=1-CDF!(UN+1):GOTO 3520
3820 GOSUB 13020
3840 CLS:PRINT@120,"If you want the data value at T1 AND T2":
3845 PRINT@215,"input an 'Y'"
3850 PRINTTAB(8);"otherwise any other letter ";
3860 INPUT X$:IF X$<>"Y" GOTO 13100
3880 GOSUB 18120
3900 GOSUB 18300
3920 CLS:PRINT:PRINTTAB(10);"T1 = ";D!(LN+1);" and T2 = ";D!(UN+1)
3930 PRINT
3940 GOSUB 13020
3960 GOTO13100
10000 '****    SUBROUTINE MENU FOR THE BINOMIALLY DISTRIBUTED TESTS
10020 PRINTTAB(18);"MENU"
10022 PRINT"1-Binomial Test";TAB(20);"2-Quantile Test"
10025 PRINT"3-Cox-Stuart test";TAB(20);"4-Quantile C.I."
10028 PRINTTAB(10);"5-Sign Test"
10040 PRINT:PRINT:"  PLEASE MAKE YOUR SELECTION <1-5>";
10060 K$=INKEY$:IF K$ ="" GOTO 10060
10080 QT=VAL(K$)
10100 IF QT>5  GOTO 10240
10120 IF QT<1  GOTO 10240
10140 RETURN
10240 CLS:PRINT@123,"You have made an improper selection"
10250 PRINTTAB(13);"to try again"
10260 PRINTTAB(7);"TO CONTINUE - STRIKE ANY KEY"
10280 K$=INKEY$:IF K$="" GOTO 10280
10300 CLS:GOTO 10020
10320 RETURN
11000 '****    SUBROUTINE FOR THE ASSUMPTIONS OF THE TESTS
11020 ON QT GOTO 11040,11260,11340,11260,11300
11040 CLS:PRINT@84,"You selected the Binomial Test"
11045 PRINTTAB(6)"this test assumes you meet the"
11050 PRINTTAB(10);"following assumptions"
11060 PRINT: GOSUB 13020
11080 CLS:PRINT@43,"1-Only Nominal Level Data";
11100 PRINT@83,"2-'P' Constant Over All Trials"
```

```
11105 PRINTTAB(3)"3-All Observations Are Independent"
11120 PRINT@203,"TO CONTINUE - STRIKE ANY KEY"
11140 PRINT@243,"If you fail the assumptions then"
11160 PRINT@283,"to return to the menu input 'M';
11180 E$=INKEY$:IF E$="" GOTO 11180
11200 IF E$<>"M" GOTO 1000
11220 CLS:GOTO 160
11240 RETURN
11260 CLS:PRINT@85,"You have selected the Quantile/CI "
11265 PRINTTAB(6);"this test assumes you meet the"
11270 PRINTTAB(10);"following assumptions":PRINT:GOSUB 13020
11280 CLS:PRINT@83,"1-Ordinal or Higher Level Data"
11290 PRINTTAB(3);"2-All Observations are IID ":GOTO 11120
11300 CLS:PRINT@84,"You have selected the Sign Test"
11305 PRINTTAB(5);"this test assumes you meet the"
11310 PRINTTAB(9)"following assumptions":PRINT:GOSUB 13020
11320 CLS:PRINT:PRINTTAB(3);"1-Ordinal or Higher Level Data"
11325 PRINTTAB(3);"2-Paired Observations"
11330 PRINTTAB(3);"3-Outcomes in 2 Classes (+ OR -)"
11335 PRINT@163,"4-Cases IID Within Classes":GOTO 11120
11340 CLS:PRINT@85,"You have selected the Cox-Stuart"
11345 PRINTTAB(6);"this test assumes you meet the"
11350 PRINTTAB(10);"following assumptions":PRINT:GOSUB 13020
11360 CLS:PRINT@83,"1-Ordinal or Higher Level Data"
11370 PRINTTAB(3);"2-All Observations Are IID":GOTO 11120
13000 '****                SUBROUTINE INKEY$
13020 PRINTTAB(7);"TO CONTINUE - STRIKE ANY KEY";
13040 K$=INKEY$: IF K$="" GOTO 13040
13060 RETURN
13100 CLS:PRINT@83, "Strike 'C' to do another test"
13110 PRINT@120,"If you are finished strike any other key"
13120  K$=INKEY$: IF K$=""GOTO13120
13140  IF K$="C" GOTO 13175
13160 CLS: END
13175 CLS:GOTO 160
13200 '****     REQUEST FOR ALPHA HATS
13210 ' VARIABLES AT=ALPHA HAT, LV=LOWER OBSERVED VALUE,
13215 ' UV=UPPER OBSERVED VALUE, OV=BINOMIAL OBSERVED VALUE
13220 CLS:PRINT@85,"Do you wish to find your actual"
13225 PRINT@131,"ALPHA HAT VALUE?"
13230 PRINT@202,"Just input 'Y' for Yes or 'N' for No"
13240 '
13260 B$=INKEY$: IF B$=""GOTO 13260
13280 IF B$="N" GOTO13100
13300 IF B$="Y" GOTO14000
13320 GOTO 13240
14000 '****  CALCULATION OF ACTUAL ALPHA HATS
14020 ON QT GOTO 14040,14300,14040,13100,14040
14040 CLS:PRINT@85,"Please input your observed 'T'";
14080 INPUT B
14100 IF B<0 OR B>N GOTO 14040
14110 IF S>1 THEN 14620
14120 IF T=1 THEN 14200
14140 IF T=2 THEN AT=CDF!(B+1)
14160 IF T=3 THEN AT=1-CDF!(B+1)
14180 CLS:PRINT@86,"ALPHA HAT is equal to";AT
14190 GOSUB 13020
14195 GOTO 13100
14200 LV=CDF!(B+1):UV=1-CDF!(B+1)
14220 IF LV<=UV THEN AT=2*LV ELSE AT=2*UV
14240 IF AT>1 THEN AT=1
14260 GOTO 14180
14300 CLS:PRINT@83, "Please input your 'T1' value";
14320 INPUT T1
14340 CLS:PRINT@83, "Please input your 'T2' value";
14360 INPUT T2:CLS
14380 IF T2>T1 THEN 14560
14400 IF T=1 THEN 14480
14420 IF T=2 THEN AT=CDF!(T1+1)
```

```
14460 GOTO 14180
14480 LV=CDF!(T1+1):UV=1-CDF!(T2+1)
14500 IF LV<=UV THEN AT=2*LV ELSE AT=2*UV
14520 IF AT>1 THEN AT=1
14540 GOTO 14180
14560 PRINT@83,"Please check your numbers and"
14565 PRINT@128,"re-input 'T1'and 'T2'"
14580 GOSUB 13020
14600 GOTO 14300
14620 IF T=1 THEN 14680
14640 IF T=2 THEN AT=CDF!(B+1)
14660 IF T=3 THEN AT=CDF!(N-B+1)
14670 GOTO 14180
14680 LV=CDF!(B+1):UV=CDF!(N-B+1)
14700 IF LV<=UV THEN AT=2*LV ELSE AT=2*UV
14720 IF AT>1 THEN AT=1
14740 GCTO 14180
15000 '****          INPUT PARAMETER SUBROUTINES
15020 '****                SUBROUTINE FOR N
15040 CLS:PRINT@125,"Please input N";
15060 INPUT N:IF N>0 THENGOTO 15120 ELSE GOTO 15240
15080 CLS:PRINT@125,"Try a positive number":FOR X=1 TO 1500:NEXTX
15100 CLS: GOTO 15040
15120  RETURN
15140 '****               SUBROUTINE FOR P
15160 CLS:PRINT@125,"Please input P(robability)";
15180 INPUT P
15200 IF P<0 OR P>1.0 GOTO 15260
15240 RETURN
15260 CLS:PRINT@125,"P must be between 0 and 1.0":FOR X=1 TO 1500
15270 NEXTX
15280 CLS:GOTO 15160
15300 RETURN
15320 '****               SUBROUTINE FOR INPUTTING ALPHA
15340 CLS:PRINT@125,"Please input the ALPHA VALUE";
15360 INPUT AT
15380 IF AT<0 OR AT>1.0 GOTO 15420
15400 GOTO 15460
15420 CLS PRINT@125,"ALPHA must be between 0 and 1.0"
15425 FOR X=1 TO 1500:NEXTX
15440 CLS:GOTO 15320
15460 RETURN
15480 '*****           SUBROUTINE FOR CRITICAL VALUE TAIL LOCATIONS -T
15500 CLS:PRINT@83,"Please select your critical region"
15505 PRINTTAB(10);"1 - Two Tailed Test"
15510 PRINTTAB(10);"2 - Lower Tail Only"
15515 PRINTTAB(10);"3 - Upper Tail Only"
15520 PRINT@284,"PLEASE MAKE YOUR SELECTION <1-3>";
15540 INPUT T
15560 IF T<1 OR T>3 GOTO 15600
15580 GOTO 15620
15600 CLS:PRINT@126,"T must be a 1,2 or 3"
15605 FOR X=1 TO 2000:NEXTX:GOTO 15500
15620 CLS:RETURN
15640 '****      THE CALCULATION OF THE BINOMIAL PDF
15660 '********          IDENTIFICATION OF VARIABLES        **********
15680 'P=PROBABILITY
15700 'PDF=PROBABILITY DENSITY FUNCTION
15720 'CDF= CUMULATIVE DISTRIBUTION FUNCTION
15740 'N=THE NUMBER OF OBSERVATIONS
15760 'K=THE NUMBER OF CLASS ONE OBSERVATIONS
15780 '**********        BINOMIAL PDF/CDF CALCULATIONS      ***********
15800 CLS:PRINT@128,"I'm calculating ":CDF=0
15820 FOR K=0 TO N
15840    I=K+1
15860    PROD=1
15880    M=K
15900 FOR X=N TO (N-K+1)STEP-1
15920   IF K=0 GOTO 16000
```

```
15940   PROD=PROD*(X/M)
15960   M=M-1
15980 NEXTX
16000 PDF!(I)=PROD*(P^K)*((1-P)^(N-K))
16020 CDF=CDF+PDF!(I):CDF!(I)=CDF
16040 NEXTK
16060 RETURN
16080 '**** SUBROUTINE FOR ALPHA VALUES FOR BINOMIALLY DISTRIBUTION
16120 ON T GOTO 16280,16780,17140
16140 '****                  TWO TAILED TEST
16160 '                          VARIABLES
16180 'H1-LOWER ALPHA OUTPUT VALUE
16200 'H2-UPPER ALPHA OUTPUT VALUE
16220 'HT-TOTAL ALPHA OUTPUT VALUE
16240 'LN-"N" - LOWER TAIL
16260 'UN-"N" - UPPER TAIL
16280 A1=(AT/2):A2=(AT/2)
16300    FOR I=1 TO (N+1)   'LOWER ALPHALOOP
16320      IF CDF!(I)=A1 GOTO 16460
16340      IF CDF!(I)>A1 GOTO 16520
16360      IF CDF!(I)<A1 THEN NEXTI
16380    FOR I=1 TO N+1   'UPPER ALPHA LOOP
16400      IF CDF!(I)>1-A2 GOTO 16640
16420      IF CDF!(I)=1-A2 GOTO 16580
16440      IF CDF!(I)<1-A2 THEN NEXTI
16460 H1=CDF!(I):LN=I-1
16480  IF LN<0 THEN LN=0
16500 GOTO 16380
16520 H1=CDF!(I-1):LN=I-2
16540  IF LN<0 THEN LN=0
16560 GOTO 16380
16580 H2=(1-CDF!(I-1)):UN=I:HT=H1+H2
16600 IF QT<>4 GOTO 16670 ELSE RETURN
16640 H2=(1-CDF!(I)):UN=I-1:HT=H1+H2
16665 IF QT=4 OR QT=2 THEN 16720
16670 GOSUB 18740
16680 PRINTTAB(2)"1.  'T' is less than or equal to ";LN
16700 PRINTTAB(2)"2.  'T' is greater than ";UN:PRINT
16720 RETURN
16740 '****                LOWER ONE TAILED TEST
16760 IF S=2 THEN AT=AT/2
16780 FOR I=1 TO (N+1)
16800   IF CDF!(I)>AT GOTO 16860
16820   IF CDF!(I)=AT GOTO 16900
16840   IF CDF!(I)<AT THEN NEXTI
16860 HT=(CDF!(I-1)):LN=I-2
16880 IF LN<0 THEN LN=0
16900 GOTO 16955
16920 HT=(CDF!(I-1)):LN=I-1
16940 IF LN<0 THEN LN=0
16955 IF QT=4 OR QT= 2 THEN 17100
16960 IF S=2 THEN HT=HT+HT
16980 IF S=2 OR S=4 THEN UN=N-LN
17000 GOSUB 18740
17020 ON S GOTO 17060,17040,17060,17080
17040 PRINTTAB(4);"'T' is greater than or equal to ";(N-LN)
17060 PRINTTAB(4);"'T' is less than or equal to ";LN:RETURN
17080 PRINTTAB(4);"'T' is greater than or equal to ";(N-LN)
17100 RETURN
17120 '****              ONE TAILED UPPER TEST
17140 FOR I=1 TO (N+1)
17160   IF CDF!(I)>1-AT GOTO 17220
17180   IF CDF!(I)=1-AT GOTO 17260
17200   IF CDF!(I)<1-AT THEN NEXT I
17220 HT=(1-CDF!(I)):UN=I-1
17240 GOTO 17275
17260 HT=(1-CDF!(I-1)):UN=I
17275 IF QT=4 OR QT=2 THEN 17340
17280 GOSUB 18740
```

```
17320 PRINTTAB(5);"'T' is greater than ";UN
17340 RETURN
18000 '****           SUBROUTINE INPUTS
18020 GOSUB 15020     'NUMBER
18040 GOSUB 15140     'PROBABILITY
18060 GOSUB 15320     'ALPHA
18080 GOSUB 15480     'NUMBER OF CRITICAL REGIONS AND LOCATIONS
18100 RETURN
18120 '****            SUBROUTINE FOR DATA INPUT
18140 FOR K=1 TO N
18160 CLS:PRINT:PRINT"  Input the value of the ";K;"TH case":PRINT
18180 PRINTTAB(18);"";
18200 INPUT D:D!(K)=D:CLS:PRINT@127,"The value '";D;"' has been"
18205 PRINT@167,"assigned to  case '";K;"'"
18220 PRINT:PRINTTAB(7);"Is this correct 'Y' or 'N'?"
18240 B$=INKEY$:IF B$="" GOTO 18240
18260 IF B$<> "Y" GOTO 18160
18280 NEXTK
18300 '****          SUBROUTINE TO DO SHELL SORT
18320 A=1.442705042
18340 L=INT(LOG(N)*A)
18360 M=N
18380 FOR I1=1 TO L
18400   M=INT(M/2)
18420   K=N-M
18440     FOR I2=1 TO K
18460        I=I2
18480        L1=I+M
18500        IF((D!(L1))<(D!(I))) GOTO 18640
18520        IF I>1 GOTO 18560
18540 PRINT
18560     NEXTI2
18580 NEXTI1
18600 'FOR X=1 TO N:PRINT D!(X):NEXTX
18620 RETURN
18640 T=D!(I)
18660 D!(I)=D!(L1)
18680 D!(L1)=T
18700 I=I-M
18720 GOTO18540
18740 '****      SUBROUTINE PRINTING OUTCOMES
18760 CLS:PRINT@85,"   ALPHA  is equal to ";HT
18770 PRINTTAB(5);"reject your null hypothesis if":RETURN
```

APPENDIX F

CHI SQUARE DISTRIBUTION PROGRAM

```
1 CLS
20 DIM X!(15,15),C!(15),R!(15),N(3),N!(3)
40 CLS:PRINT@123," Initial program load in progress"
50 A=8:N=0:CS=3:T=1:MN=0:SD=1:TS=0
60 FOR I=1 TO 15:R!(I)=0:NEXT
80 FOR J=1 TO 15:C!(J)=0:NEXT
100 FOR I=1 TO 15:FOR J=1 TO 15
110  X!(I,J)=0
120 NEXT:NEXT
140 '***** VARIABLE LIST
160 ' X!(RT,CT)-ARRAY OF TABLE CELLS// R!(RT)-VECTOR OF ROW TOTALS//
162 ' C!(CT)-VECTOR OF COLUMN TOTALS//DF-DEGREES OF FREEDOM//
164 ' EX-EXPECTED CELL FREQUENCY// TS-TEST STATISTIC//
166 ' QT= TEST SELECTED//T= TAIL LOCATION OF CRITICAL REGION
180 ' CI-CONFIDENCE INTERVAL// R,M-VARIABLES IN TOLERANCE LIMITS//
182 ' PA-THE ALPHA LEVEL// Q-CERTAINTY LEVEL
200  CLS:GOSUB 10000   'THIS  IS THE CHI SQUARE MENU SUBROUTINE
220 CLS:PRINT@83,"Do you wish to check the assumptions"
230 PRINT@123,"of the test that you have selected?"
235 PRINT@203,"input 'Y' for yes or 'N' for no;
240 B$=INKEY$:IF B$="" GOTO 240
260 IF B$="Y" OR B$="y" GOTO 320
280 IF B$="N" OR B$="n" GOTO 900
300 GOTO 240
320 GOSUB 11000 'SUBROUTINE OF ASSUMPTIONS
900 ON QT GOTO 1000,2000,3000,4000,5000,6000
1000 '****   TOLERANCE LIMITS
1001 '
1020 CLS:PRINT@82,"What Confidence Interval do you want?"
1030 PRINT:PRINT@167,"(.90,.95,Your Choice)";
1040 INPUT CI:PA=1-CI
1060 CLS:PRINT@82,"What is the population proportion?"
1062 PRINT:PRINT@170,"(Q Value)";
1080 INPUT Q
1100 CLS:PRINT@127,"What value for 'R'";
1120 INPUT R
1140 PRINT@167,"What value for 'M'";
1160 INPUT M:CLS:DF=2*(R+M)
1170 IF DF = 0 THEN 1100
1180 GOSUB 17000
1200 N=.25*TS*((1+Q)/(1-Q))+.5*(R+M-1)
1220 PRINT@86,"To be ";CI;" confident you need "
1230 PRINT@127," an N > or = to ";N
1240 PRINT:GOTO 5200
2000 '****   MCNEMAR TEST FOR N >20
2001 '
2020 RT=2:CT=2:DF=1
2040 GOSUB 15000
2060   IF (X!(1,2)+X!(2,1))<20 THEN 2200
2080 TS=((X!(1,2)-X!(2,1))-2)/(X!(1,2)+X!(2,1))
2100 GOSUB 16000
2120 GOTO 5140
2200 CLS:PRINT@82,"Sorry N is too small -we'll start over"
2220 FOR X=1 TO 1000:NEXTX:CLS:GOTO 40
3000 '****   COCHRAN TEST FOR RELATED SAMPLES
3001 '
3020 CT=0:RT=0:N=0:TS=0:CLS:PRINT@123,"How many columns do you have";
3040 INPUT C
3060  FOR I=1 TO C
3080    CLS:PRINT@123,"Input the column ";I;" total";
```

```
3100     INPUT K
3120     CT= CT+(K*K)
3140     N=N+K
3160   NEXT I
3180     TT=(C*(C-1)*CT)-((C-1)*(N*N))
3200 CLS:PRINT@123,"How many rows do you have";
3220 INPUT R
3240   FOR I= 1 TO R
3260    CLS:PRINT@123,"Input the row ";I;" total";
3280     INPUT K
3300     RT=RT+(K*K)
3320   NEXT I
3340 CLS:  TB=(C*N)-RT
3360 TS=((TT)/(TB)):DF=(C-1)
3380 GOSUB 16000
3400 GOTO 5140
4000 '****   MEDIAN TEST
4001 '
4020 GOSUB 13500     'INPUT ROW AND COLUMN TOTALS
4040 GOSUB 15000     'INPUT TABLE VALUES
4060 ID=ABS((R!(1))-(R!(2)))
4080 IF ID<=1 THEN 4100 ELSE 4140
4100 GOSUB 16000     'CALCULATE CHI SQUARE DISTRIBUTION
4120 GOTO 5140
4140 CLS:PRINT@43,"Row 1 and row 2 totals should be"
4145 PRINT@83,"approximately equal. Do you want"
4147 PRINT@128,"to reinput your numbers?"
4148 PRINT:PRINT@203,"Input a 'Y'for yes or 'N' for no";
4160 INPUT B$
4180 IF B$="Y" GOTO4000
4200 IF B$="N" GOTO4100
4220 GOTO 4140
4999 '
5000 '****   CHI SQUARE TEST
5002 '
5020 GOSUB 13500       'SUBROUTINE FOR COLUMN AND ROW INPUTS
5040   IF (RT=2) AND (CT=2) THEN 5500      'Gets critical tail values
5060 GOSUB 15000      'SUBROUTINE TO FILL TABLE
5080   IF CS=0 THEN 5700
5100 GOSUB 16000      'SUBROUTINE TO CALCULATE CHI SQUARE DISTRIBUTION
5120 IF T>1 THEN 5780
5140 CS!=CS:TS!=TS:CLS:PRINT@47,"Your test statistic is "
5150 PRINT@93,"equal to  ";TS!
5160 PRINT@126," your 'Alpha Hat' is";1-CS!:PRINT
5200 GOSUB 13000
5220 GOSUB 13100
5500 '**** Selection of Critical Region
5520 CLS:PRINT@83,"Please select your critical region "
5525 PRINT@130,"1 - Two Tailed Test"
5530 PRINT@170,"2 - Lower Tail Only"
5535 PRINT@210,"3 - Upper Tail Only"
5540 PRINT@284,"PLEASE MAKE YOUR SELECTION <1-3>";
5560 K$=INKEY$:IF K$=""GOTO 5560
5580 T=VAL(K$)
5600 IF (T<1) OR (T>3) GOTO 5560
5620 GOTO 5060
5666 END
5700 '****  Results in wrong tail
5720 CLS:PRINT@83,"Your results lie in the wrong tail."
5725 PRINTTAB(8)"You will never reject your"
5730 PRINTTAB(13)"null hypothesis."
5740 GOSUB 13000
5760 GOSUB 13100
5761 '
5762 '
5780 '****   Calculation of one tailed alpha value
5800 X9=TS:GOSUB 16140    'Normal calculations given T>1
5820 GOTO 5140
6000 '****   GOODNESS OF FIT TEST - CHI SQUARE
```

```
6020 GOSUB 9000
6021 CLS:PRINT@82,"Please input the number of classes";
6022 INPUT CT
6040 ON TD GOTO 6060,7000,7000 'NORMAL, UNIFORM, EXPONENTIAL
6060 CLS:PRINT@86,"Please input the mean of your"
6070 PRINT@126,"theoretical distribution";
6080 INPUT MN
6100 PRINT@166,"Now enter the variance of the"
6110 PRINT@206,"theoretical distribution";
6120 INPUT VA
6180   FOR J=1 TO (CT-1)
6200     PA=(1/CT)*J
6220     GOSUB 18000
6240     N!(1)=MN+SQR(VA)*IZ
6260     IF J=1 THEN 6500
6280 CLS:PRINT@80,"Input the # of observed data points that"
6290 PRINT@122,"are >";N!(0);"and < or =";N!(1);
6300 INPUT C!(J)
6320 N=N+C!(J)
6340 N!(0)=N!(1)
6360 CLS:NEXT
6380 PRINT@82,"Input the # of observed data points"
6385 PRINT@132," > ";N!(1);
6400 INPUT C!(CT):N=N+C!(CT)
6410 CLS:PRINT@122,"How many parameters did you estimate"
6415 PRINT@215,"(0, 1, OR 2)";
6420 INPUT XX:IF XX<0 OR XX>2 GOTO 6410
6425 DF=CT-(XX+1):EX=N/CT
6430 FOR I= 1 TO CT
6440   TS=TS+((C!(I)-EX)¬2)/EX:NEXT
6460   GOSUB 16000
6480   GOTO 5140
6500 CLS:PRINT@83,"Input the # of observed data points"
6510 PRINT@135,"< or = ";N!(1);
6520 INPUT C!(J):GOTO 6320
7000 '**** UNIFORM DISTRIBUTION AND POISSON DISTRIBUTION
7010 IF TD=2 THEN 7100
7020 CLS:PRINT@45,"Please note - your classes are"
7022 PRINTTAB(6)"assumed to run from 0 to";(CT-1)
7024 PRINTTAB(6)"If you fail this assumption"
7026 PRINTTAB(6)"to return to the input menu"
7028 PRINTTAB(12)" STRIKE 'M'"
7030 PRINTTAB(5)" ANY OTHER KEY TO CONTINUE"
7040 E$=INKEY$:IF E$=""GOTO 7040
7060 IF E$<>"M" THEN 7080
7070 CLS:GOTO 40
7080 CLS:PRINT@125,"Please input LAMBDA";
7090 INPUT MN
7100 FOR J= 1 TO CT
7110   IF TD=2 THEN I=J ELSE I=J-1
7120 CLS:PRINT@46,"Input the number in column ":PRINT@135,"COLUMN- ";I;
7140 INPUT C!(J):N=N +C!(J):CLS
7160 NEXT:IF TD=2 THEN 6410
7180 '**** ENTERING POISSON LOOP
7200 EX=EXP(-MN)*N:EX=EX+.5:EX=INT(EX)
7210     IF EX=0 THEN 7500
7220 TS=TS+((C!(1)-EX)¬2)/EX
7240 I=0:PROD=1
7260 FOR J=2 TO CT
7280  I=I+1:PROD=PROD*I
7300  EX=N*(((MN)¬I)*EXP(-MN))/PROD:EX=INT(EX+.5)
7310    IF EX=0 THEN 7540
7320  TS=TS+((C!(J)-EX)¬2)/EX
7340 NEXTJ
7360 CLS:PRINT@122,"Did you estimate lambda from your data"
7370 PRINT@210, " 'Y' for yes, or 'N' for no"
7380 INPUT E$
7400 IF E$="Y" THEN DF=CT-2:CLS:GOTO 6460
7420 IF E$="N" THEN DF=CT-1:CLS:GOTO 6460
```

```
7440 GOTO 7360
7500 CLS:PRINT@82,"Sorry, the expected value in the cell"
7510 PRINT@125,"is 0, you need to collapse cells."
7520 GOSUB 5200
7540 CLS:PRINT@83,"I have collapsed all cells larger"
7550 PRINT@130,"than or equal to";I
7560 GOSUB 13000
7580 GOTO 7360
9000 '****  THEORETICAL DISTRIBUTION
9020 CLS:PRINT@41,"Select your theoretical distribution"
9022 PRINT@128,"1- Normal Distribution"
9024 PRINT@168,"2- Uniform Distribution"
9026 PRINT@208,"3- Poisson Distribution"
9040 PRINT@284,"PLEASE MAKE YOUR SELECTION <1-3>";
9060 K$=INKEY$:IF K$ =""GOTO 9060
9080 TD=VAL(K$)
9100 IF (TD>3) OR (TD<1) GOTO 9060
9120 RETURN
10000 '****  SUBROUTINE MENU FOR CHI-SQUARE DISTRIBUTED TESTS
10020 PRINTTAB(18);"MENU"
10022 PRINT"1-Tolerance Limits";TAB(20);"2-McNemar Test"
10024 PRINT"3-Cochran Test";TAB(20);"4-Median Test"
10026 PRINT"5-Chi-Square Test";TAB(20);"6-Goodness of fit"
10040 PRINT:PRINT;"   PLEASE MAKE YOUR SELECTION <1-6>";
10060 K$=INKEY$:IF K$=""GOTO 10060
10080 QT=VAL(K$)
10100 IF (QT>6) OR (QT<1) GOTO 10060
10120 RETURN
11000 '**** SUBROUTINE FOR THE TEST ASSUMPTIONS
11020 ON QT GOTO 11040,11200,11280,11340,11420,11480
11040 CLS:PRINT@86,"You selected Tolerance Limits":GOSUB 12800
11060 GOSUB 13000
11080 CLS:PRINT@43,"1-The X's are a random sample"
11090 PRINT@83,"2-Ordinal level data"
11100 PRINT@203,"TO CONTINUE - STRIKE ANY KEY"
11120 PRINT@243,"If you fail the assumptions then"
11130 PRINT@283,"to return to the menu input 'M'";
11140 E$=INKEY$:IF E$="" GOTO 11140
11160 IF E$<>"M" GOTO 900
11180 CLS:GOTO 160
11200 CLS:PRINT@85,"You have selected the McNemar test":GOSUB 12800
11220 GOSUB 13000
11240 CLS:PRINT@42,"1-'N' equal or greater than 20"
11245 PRINT@82,"2-The pairs (X,Y) are mutually"
11247 PRINT@125,"independent"
11250 PRINT@162,"3-Nominal level data in two categories":PRINT
11255 GOSUB 13000
11260 CLS:PRINT@123,"If you failed the assumptions then"
11270 PRINT@163,"to return to the menu input 'M'":GOTO 11140
11280 CLS:PRINT@84,"You have selected the Cochran test":GOSUB 12800
11300 GOSUB 13000
11320 CLS:PRINT@82,"1-Randomly selected treatment blocks"
11325 PRINT@122,"2-Dichotomous treatment outcomes (0,1)":GOTO 11100
11340 CLS:PRINT@83,"You have selected the Median test":GOSUB 12800
11360 GOSUB 13000
11380 CLS:PRINT@42,"1-Independent random samples"
11385 PRINT@82,"2-At least ordinal level data"
11390 PRINT@122,"3-All populations have the same median"
11400 GOTO 11100
11420 CLS:PRINT@43,"You have selected the Chi Square test":GOSUB 12800
11440 GOSUB 13000
11460 CLS:PRINT@42,"1-Independent random samples"
11470 PRINT@82,"2-Each observation is classified into"
11472 PRINTTAB(4)"only one row and one column":PRINT:GOTO 11100
11480 CLS:PRINT@42,"You have selected the Goodness of fit":GOSUB 12800
11500 GOSUB 13000
11520 CLS:PRINT@43,"1-An independent random sample"
11530 PRINT@83,"2-Data level appropriate to"
11533 PRINT@125,"the distribution selected":GOTO 11100
```

```
12800 PRINTTAB(6)"this test assumes you meet the"
12820 PRINTTAB(10)"following assumptions":PRINT:RETURN
12999 '
13000 '****       SUBROUTINE INKEY$
13001 '
13020 PRINTTAB(7); "TO CONTINUE - STRIKE ANY KEY";
13040 K$=INKEY$:IF K$="" GOTO 13040
13060 RETURN
13100 CLS:PRINT@83, "Strike 'C' to do another test"
13110 PRINT@120,"If you are finished strike any other key"
13120 K$=INKEY$:IF K$=""GOTO 13120
13140 IF K$="C" GOTO 13180
13160 CLS:END
13180 CLS:GOTO 40
13499 '
13500 '****       SUBROUTINE ROW AND COLUMN INPUTS
13501 '
13520 CLS:PRINT@83,"Please enter the number of rows in"
13530 PRINT@127," the contingency table";
13540 INPUT RT
13560 PRINT@163," Now enter the number of columns";
13580 INPUT CT:IF (QT=4) AND (RT<>2) THEN 13620
13600 DF=(CT-1)*(RT-1):RETURN
13620 CLS:PRINT@125,"You are permitted only '2' rows"
13622 PRINTTAB(11)"in the Median Test"
13640 GOSUB 13000
13660 CLS:GOTO 13520
14999 '
15000 '****       SUBROUTINE TABLE INPUTS
15002 '
15010 N=0
15200 FOR I=1TO RT:FOR J=1TO CT
15220 CLS:PRINT@46,"Input the number in the cell in"
15225 PRINT@135,"ROW- ";I:PRINT@175,"COLUMN- ";J
15240 PRINT@251,"THE NUMBER ";
15260 INPUT X!(I,J):CLS
15280 NEXT:NEXT
15300  FOR I=1 TO RT
15320       R!(I)=0
15340    FOR J=1 TO CT
15360         R!(I)=R!(I)+X!(I,J)
15380    NEXTJ
15400       N=N+R!(I)
15420  NEXTI
15440  FOR J=1 TO CT
15460       C!(J)=0
15480    FOR I=1 TO RT
15500         C!(J)=C!(J)+X!(I,J)
15520  NEXTI:NEXTJ
15523    IF QT=4 GOTO 15770
15525    IF QT=2 GOTO 15660
15530     IF T>2 GOTO 15700
15540  IF RT<>2 AND CT<>2 GOTO 15560
15545 AB=(ABS(X!(1,1)*X!(2,2)-X!(1,2)*X!(2,1))->2)
15548 TS =(AB*N)/(R!(1)*R!(2)*C!(1)*C!(2))
15550 RETURN
15560 FOR I=1TO RT:FOR J=1TO CT
15580  EX=R!(I)*C!(J)/N:TS=TS+((X!(I,J)-EX)->2)/EX
15600   IF EX<5 THEN CF=CF+1
15620   IF EX>1 THEN CO=CO+1
15640 NEXTJ:NEXTI
15560 RETURN
15700 S1=((X!(1,1)*X!(2,2)-X!(1,2)*X!(2,1))*SQR(N))
15705 S2=(SQR(R!(1)*R!(2)*C!(1)*C!(2)))
15710 TS= S1/S2
15720   IF (T=2) AND (TS>0) THEN CS=0
15740   IF (T=3) AND (TS<0) THEN CS=0
15760 RETURN
15770 S1=(N->2)/(R!(1)*R!(2))
```

```
15780 S2=0
15790 FOR I=1 TO CT
15795   S3=(C'(I)*R'(I))/N
15800   S2=S2+((X'(1,I)-S3)^2)/(C'(I))
15810 NEXT I
15820 TS=S1*S2:RETURN
15998 '
15999 '
16000 '****     SUBROUTINE TO CALCULATE CHI-SQUARE DISTRIBUTION
16001 '
16005 IF TS=0 THEN 16999
16010 IF DF=0 THEN 16999
16015 CLS:PRINT@130,"I'm calculating"
16020 IF DF<4[illegible] THEN GOTO 16500
16040 '**** NORMAL DISTRIBUTION APPROXIMATION STEPS
16060 Y9=(((TS/DF)^(1/3)-1)+2/(9*DF))/SQR(2):Y9=Y9*3*SQR(DF)
16080 IF Y9<-4.3 THEN CS=0:GOTO 16400
16100 IF Y9>4.3 THEN CS=1:GOTO 16400
16120 MN=0:SD=1:X9=TS:TS=Y9
16130 '**** NORMAL CALCULATIONS
16140 XL=TS:TS=ABS((TS-MN)/SD):RL=EXP(-(TS*TS)/2)/2.506628
16160 TS=1/(1+.33267*TS):TL=.5-RL*((.937298*TS-.1201676)*TS+.4361836)*TS
16180 IF XL<MN THEN Z=.5-TL:TS=XL
16200 Z=TL+.5:TS=XL
16220 '****     THIS ENDS NORMAL CALCULATIONS
16240 TS=X9:CS=Z
16400 RETURN
16500 DL=DF:D9=1
16520 D9=D9*DL:DL=DL-2:IF DL>=2 THEN 16520
16540 P9=INT((DF+1)/2):N9=EXP(P9*LOG(TS)-TS/2)/D9
16560 DL=DF:E9=.0000001:F9=1E+07:L9=1:M9=1:J9=1
16580 IF DF-2*INT(DF/2)=1 THEN J9=SQR(2/TS/3.141592654)
16600 DL=DL+2:M9=M9*TS/DL:L9=L9+M9
16620 IF M9>F9 THEN CS=1:RETURN
16640 IF M9>E9 GOTO 16600
16660 L9=L9-M9:CS=J9*N9*L9:RETURN
16999 CS = 0:RETURN
17000 '**** INVERSE CHI SQUARE DISTR. BY RECURSION
17002 '
17004 CLS:PRINT@130,"I'm calculating"
17040 N(1)=N(0)+A
17041    TS=N(1)
17060    GOSUB 16000
17080    IF (1-CS)<PA THEN 17120
17100    N(0)=N(1):GOTO 17040
17120    FL=FL+1
17140 CLS:PRINT@134, "Still Going":IF FL=3 GOTO 17240
17160    IF FL=5 GOTO 17260
17180    IF FL= 6 THEN 17220
17200    A=A/4:GOTO 17040
17220  CLS:RETURN
17240 PRINT@170, " I'm nearly finished":GOTO 17180
17260 PRINT@170, " The last loop to do":GOTO 17180
17999 '
18000 '****  INVERSE NORMAL DISTRIBUTION
18002 '
18011 P8=PA:IF PA>.5 THEN PA= 1-PA
18020 TL=SQR(LOG(1/(PA*PA)))
18040 RL=(.010328*TL+.802853)*TL +2.515517
18060 RL=RL/(((.001308*TL+.189269)*TL+1.432788)*TL+1)
18080 IZ=RL-TL:IF P8>.5 THEN IZ=-IZ
18140 RETURN
18150 END
```

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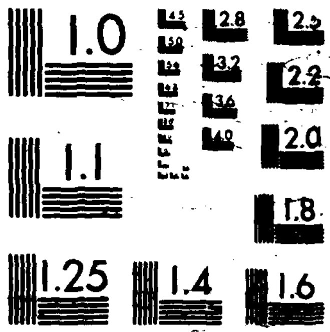
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