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STATISTICS PROGRAMS FOR
THE TI-59 CALCULATOR

by

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Thesis Advisor: D. R. Barr

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This paper presents a package of nine programs for the TI-59 calculator. This package was developed as a solution to two problems. One problem involved expanding and modifying an existing set of programs; and a second problem involved developing five distribution approximating programs. The solution to these problems represents a package with considerable capability in computing confidence intervals, performing

hypothesis tests and approximating distribution values. The distribution approximations include inverse CDF values for the Normal, Chi-square, Student's t and F distributions, which allow the computation of confidence intervals without using tables.

The TI-59 proved to be a useful tool in solving these problems and demonstrated the capability of hand-held programmable calculators. The comprehensive set of user guides included in this programming package provides even the inexperienced user with a step-by-step introduction to this capability. Additionally, the methods used in preparing this programming package are directly applicable to other calculators or computers.

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Statistics Programs for the TI-59 Calculator

by

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TABLE OF SYMBOLS

α	Significance level
γ	Confidence level, $(1-\alpha)$
θ	Arbitrary distribution parameter
μ	Population mean
v	Degrees of freedom
ρ	Population correlation coefficient
σ	Population standard deviation
σ^2	Population variance
χ^2	Chi-square distribution
$\chi^2_p(v)$	Chi-square p^{th} percentile with v degrees of freedom
$\square$	Symbol for calculator keystroke
a	Arbitrary constant
b	Arbitrary constant
d_i	Data point from sample of differences $x_i - y_i$
F	Symbol for F distribution
$F_p(v_1,v_2)$	F p^{th} percentile with v_1 and v_2 degrees of freedom
i	Counting index
k	Number of separate sets in multinomial distribution
l	Lower confidence bound
m	Number of data points in sample y
n	Number of data points in sample x
$N(\mu,\sigma)$	Normal distribution
p	Probability value
r	Sample correlation coefficient
R_{00}	Storage register 00 to 99

s	Sample standard deviation
s^2	Sample variance
s_d	Sample standard deviation for difference $d_i = x_i - y_i$
S	Population standard deviation
S^2	Population variance
t	Student's t distribution
$t_p(v)$	Student's t p^{th} percentile with v degrees of freedom
u	Upper confidence bound
$\overline{x}$	Sample mean for x_i's
x_i	Data point from sample x
$\overline{y}$	Sample mean for y_i's
y_i	Data point from sample y
z_p	Normal p^{th} percentile

I. INTRODUCTION

The purpose of this paper is to trace the development of a package of nine programs for use in the TI-59 calculator. Two of these programs compute confidence intervals for either the one-population or two-population situations. Another two programs perform hypothesis testing, again, for either one- or two-population situations. The remaining five programs generate approximate distribution values for the Normal, Binomial/Multinomial, Chi-square, Student's t and F distributions.

The basis for this programming effort was a set of four TI-59 programs written by Professor P. W. Zehna for his personal use and later used in the classroom. Professor Zehna's programs also computed confidence intervals and performed hypothesis testing. However, his programs were not completely user-friendly, especially in terms of user guides; and they were dependent on obtaining some percentile values from standard tables. This paper then presents a significant expansion in the scope of these early programs. The main thrust of this expansion includes a simplified and standardized set of programs and user guides, while eliminating the dependence on distribution tables.

This package of nine programs was designed for two types of users: the student, who might be asked to quickly solve several very different problems in succession; and the working analyst, whose main concern is one specific problem which requires great accuracy. Of particular importance to both types of users is a detailed set of user guides (Appendix A) which includes sample problems. Many of these sample problems have been solved in two ways; the first way involves using program-generated percentiles; the other way requires input of tabled percentiles. While it is not absolutely necessary to look up tabled values when using the confidence interval programs, that option has been included, and should be used when increased accuracy is desired. Except for some cases involving small degrees of freedom, however, the accuracy of these first two programs is quite good as can be seen in the sample problems of Appendix A. When tables are not available, the percentile values generated by the five distributional programs is outstanding (Appendix B) and can be used in lieu of tabled values. One very convenient feature of the distribution programs is the ability to provide values normally available only by interpolation in the standard tables. It should be noted that the methods used to generate approximations in the confidence interval program is slightly less accurate than those used in the distribution programs. This difference is due to the limited number of program steps available in the first two programs. Except for the two hypothesis testing programs, there is no requirement to use the applied statistics module in the TI-59. However, this module is required when performing hypothesis testing because of the large program size and the need to provide a significance level with each test. Thus, it was possible to provide detailed, yet simple, user guides to implement theoretically correct and accurate programs. By providing the option of using either approximations or tabled values, both the student and the analyst can accurately solve a variety of problems.

II. NATURE OF THE PROBLEM

The programming effort presented in this paper was generated by two major problems. The foremost problem involved expanding and modifying an existing set of TI-59 programs into a more user-friendly package. A second, closely related problem was adding the capability for generating accurate distribution approximations. The following discussion of the solutions to these two problems is a general overview of the particular solutions used. The specific methods and theory of solution are left for later sections in this paper.

A. USER-FRIENDLY PROGRAMMING

User-friendly programming implies programming with the user's knowledge, ability, and hardware familiarity in mind. In this light, a user-friendly program is a program which has significant capability, yet can be used by those with only a modest knowledge of either the calculator or the theory involved. Applying this definition as a framework for providing a user-friendly programming package resulted in four areas of effort. These areas are: standardized data entry, standardized solution procedures, maximized use of calculator capabilities, and improved user guides.

1. Standardized Data Entry

The nine programs in this package all require some form of data entry. The data entry schemes for the confidence interval and hypothesis testing programs need careful standardization because of the similarity of the data and the size of the data sets involved. There are three possible types of data in these first four programs. Data may be from a one-population sample, a two-population paired sample, or a two-population independent sample. Any of these data can be easily entered in the form of summary statistics, if available; however, raw data requires some standardization between programs. The data entry schemes of the first four programs use similar data entry subroutines which take advantage of the TI-59's data entry sequence. In each of these programs, the data entry subroutine is initiated by pressing $\boxed{\text{D}}$. The sequence of data entry then differs slightly depending on the type of data being entered. All of these entry subroutines use a format which requires a $\boxed{\text{R/S}}$ to be pressed after each data point entry. This method saves one keystroke for each data point compared to the TI-59's two-keystroke, $\boxed{\text{2nd}}$ $\boxed{\Sigma +}$, entry method. Also, the $\boxed{\text{R/S}}$ key is very close to the numerical keyboard, compared to the $\boxed{\text{2nd}}$ key, thereby eliminating a source of data entry errors that frequently occur when using the $\boxed{\text{2nd}}$ $\boxed{\Sigma +}$ sequence.

The data entry schemes used for the five distribution programs presented no standardization problem. All of these programs, except the Multinomial, require only a few parameter entries. In the Multinomial program, which can accept as many as 35 pairs of parameters, the data entry problem was more difficult. Each of the multinomial data points is stored separately until computation begins. The data entry sequence automatically repartitions the calculator to make room for this potentially large amount of data.

Data stored directly in registers has been somewhat standardized between programs by using the same registers, where possible, for similar data. More information concerning the contents of data storage registers can be found in Appendix A.

2. Standardized Solution Procedures

A considerable effort was made to standardize the steps required in each problem solution sequence. In the two confidence interval programs (see Appendix A) problems are solved in three steps. In the first step, the calculator is repartitioned and the data are entered. The second step requires entry of either a percentage, in which case the program generates an approximate percentile, or a previously obtained percentile value. The last step involves the selection and initiation of the proper solution subroutine. A similar three-step sequence is used in the two hypothesis testing programs where the first step includes repartitioning and entry of test parameters. The second step involves data entry, and the third step, subroutine initiation.

The five distribution programs contain only a limited amount of standardization due to the different nature of the programs. The Normal, Chi-square, Student's t, and F programs use the $\boxed{A}$, $\boxed{B}$, $\boxed{C}$ labels for the same basic functions. The $\boxed{A}$ label is used in the Normal, Chi-square, and Student's t (not F) to generate approximate density values. The $\boxed{B}$ label is used to generate CDF approximations in all four of these programs, where similarly, the $\boxed{C}$ label is used to generate inverse CDF approximations. The Binomial/Multinomial program shares none of these standardized label uses.

3. <u>Maximized Use of Calculator Capabilities</u>

The ability of the TI-59 to repartition was the basis for the expansion in capability over that achieved by Professor Zehna's original programs. Repartitioning allows the addition of the program steps necessary for the inverse CDF approximating subroutines in the confidence interval programs. The added programming space was also used to compute one confidence interval estimate, for σ^2 with μ known, which was not available in the original programs. Additionally, repartitioning makes possible an F distribution program and a Multinomial distribution program.

However, repartitioning is not without its price. The larger programs now require three edges of the magnetic program cards, which presents a slight inconvenience in added loading and storage requirements. Other problems associated with repartitioning, such as inadvertent loss of program steps and unwanted or improper partitioning, have hopefully been eliminated from this programming package by extensive validation with sample problems.

4. <u>Improved User Guides</u>

Preparation of improved user guides was a key element in making a user-friendly programming package. The complexity of the programs involved and the intended use by students necessitated a departure from the standard TI-59 program record sheet. As can be seen in Appendix A, the improved user guides are organized with the user in mind. The general outline for each user guide follows this pattern:

a. Introduction

b. General Procedures

c. Specific Procedures

d. Additional Capabilities

e. Labels Used

f. Storage Register Contents

g. Sample Problems

The user guides for the five distrubiton programs have been combined to take advantage of the relative simplicity in using these programs. The answers to each sample problems are in a 10-digit format to provide a positive check on calculator output when working each problem. The confidence interval sample problems are solved in two ways to demonstrate the differences between using approximations and tabled values for the required percentiles.

B. ACCURATE DISTRIBUTION APPROXIMATIONS

The second major problem addressed in this section involves generating distribution approximations for both the confidence interval programs and the distribution programs. The capability to compute accurate distribution approximations provides a new dimension to this programming package by eliminating the need for standard distribution tables when solving confidence interval problems. A drawback of this new capability is the time required to obtain some values from the approximating programs. The time required by the confidence interval approximations is not nearly as long as that for the distribution programs; but then, the quality of the approximations is not as good either (see Section III).

Appendix B contains comparisons of tabled values with both the confidence interval program approximations (Type I) and the distribution program approximations (Type II). The actual probability values used in these comparisons were obtained using the distribution programs and can be regarded as being very close to the actual probability achieved. The missing values in the inverse F comparison are due to the inability of the Type I approximation to generate inverse F values when either of the degrees of freedom parameters is one. Also, while only selected approximations are listed in the comparison, the inverse CDF approximations are of nearly equal quality over the entire range of the appropriate function. The Type I approximations displayed in Appendix B are generally not as accurate as Type II approximations in terms of actual probability achieved. Only the inverse CDF approximations for the Chi-square, t, and F distributions are presented in Appendix B since all the other approximations which are available in the distribution programs duplicate table entries. These other approximations include probability values, CDF values, and various other distribution values (see Appendix A). The superior quality of these approximations can be attributed to using the same approximating methods used in the TI-59 Applied Statistics Module (see Section III).

III. THEORY

This section on theory is presented as a background for the solution methods used in the accompanying programs. As such, it is not intended to be a primer in statistics. Instead, this section should be considered as an intermediate level derivation of the specific statistical methods used in programming. For a more basic explanation of this material, the references cited within each subject area, or equivalent texts, should be consulted.

There are five subject areas discussed in this section. First, the theory used for estimating confidence intervals in the first two programs is discussed. Next, the hypothesis testing theory necessary for programs three and four is discussed. And lastly, the methods used in all nine programs to obtain approximations to distribution values are discussed.

A. THEORY FOR ONE-POPULATION CONFIDENCE INTERVAL ESTIMATION

The derivation of theoretical interval estimates will be done in the same order as these estimates appear in the User Guide for Program 1 (Appendix A). Most of these derivations use the pivotal-qualtity method to obtain confidence intervals (1,u) [Ref. 1: pp. 379-389]. Other methods used here will be discussed in slightly more detail, but will still be brief compared to the referenced texts. When forming a C.I. with a nonsymmetric distribution the interval will represent an equal tails solution, where equal tails implies

$P[X < l] = P[X > u] = (1-\gamma)/2$. This method does not provide the shortest C.I. for a given γ; however, this method is commonly used for its ease of computation [Ref. 1: p. 382]. Regardless of the method used, the resulting C.I. given in this section by (l,u) represents the formula used to calculate interval estimates.

1. C.I. for Normal μ with σ^2 Known [Ref. 2: pp. 77-80]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $(\bar{X}-\mu)/(\sigma/\sqrt{n})$ as the pivotal-quantity, a 100γ% C.I. is constructed thus:

$$P\left[z_{(1-\gamma)/2} < (\bar{X}-\mu)/(\sigma/\sqrt{n}) < z_{(1+\gamma)/2}\right] = \gamma.$$

Substituting $z = z_{(1+\gamma)/2} = -z_{(1-\gamma)/2}$ and simplifying we have:

$$P\left[\bar{X} - z\sigma/\sqrt{n} < \mu < \bar{X} + z\sigma/\sqrt{n}\right] = \gamma, \text{ or}$$

$$(l,u) = (\bar{x} - z\sigma/\sqrt{n}\ ,\ \bar{x} + z\sigma/\sqrt{n}).$$

2. C.I. for Normal μ with σ^2 Unknown [Ref. 2: p. 80; Ref. 3: p. 277; Ref. 1: p. 381]

Assuming X is distributed $N(\mu, \sigma^2)$ and using $(\bar{X}-\mu)/(s/\sqrt{n})$, which is distributed $t(n-1)$, as the pivotal-quantity, a 100γ% C.I. is constructed thus:

$$P\left[t_{(1-\gamma)/2}(n-1) < (\bar{X}-\mu)/(s/\sqrt{n}) < t_{(1+\gamma)/2}\right] = \gamma.$$

Substituting $t = t_{(1+\gamma)/2}(n-1) = -t_{(1-\gamma)/2}(n-1)$ and simplifying we have:

$$P\left[\bar{X} - ts/\sqrt{n} < \mu < \bar{X} + ts/\sqrt{n}\right] = \gamma \text{, or}$$

$$(l,u) = (\bar{x} - ts/\sqrt{n}\,,\ \bar{x} + ts/\sqrt{n}).$$

3. <u>C.I. for Bernoulli p</u> [Ref. 4: pp. 376-381]

The pivotal-quantity method does not work for the Bernoulli case and another method will be briefly developed here. This method starts with two numbers a and b such that

$$P\left[a < \bar{X} < b\right] = \gamma .$$

From these limits we have:

$$P\left[\bar{X} \leq a\right] = (1-\gamma)/2 = P\left[\bar{X} \geq b\right] \text{, or equivalently,}$$

$$P\left[\sum X_i \leq na\right] = (1-\gamma)/2 = P\left[\sum X_i \geq nb\right] .$$

Now $\sum X_i$ is distributed Binomial (n,p) which, for $k < n$, can be explicitly related to the incomplete Beta function and hence to the F distribution to yield:

$$u = \frac{(n\bar{X} + 1)F_{(1+\gamma)/2}(v_1, v_2)}{(n - n\bar{X}) + (n\bar{X} + 1)F_{(1+\gamma)/2}(v_1, v_2)}$$

$$l = \frac{n\bar{X}}{(n\bar{X} + (n - n\bar{X} + 1)F_{(1+\gamma)/2}(v_2+2, v_1-2)}$$

where $v_1 = (2n\bar{X} + 2)$, and $v_2 = (2n - 2n\bar{X})$

l and u form a $100\gamma\%$ conservative random interval thus:

$$P\left[l < p < u\right] \geq \gamma.$$

The outcome (l,u) is a conservative C.I. in the sense that for this discrete distribution the confidence that (l,u) contains p is at least 100γ%.

4. <u>C.I. for Normal σ^2 with μ Known</u> [Ref. 3: p. 275]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $\sum((X_i - \mu)/\sigma)^2$, which is distributed $\chi^2(n)$, as the pivotal-quantity, a 100γ% equal tails C.I. is constructed thus:

$$P\left[\chi^2_{(1-\gamma)/2}(n) < \sum(X_i-\mu)^2/\sigma^2 < \chi^2_{(1+\gamma)/2}(n)\right] = \gamma$$

Substituting $q_1 = \chi^2_{(1-\gamma)/2}(n)$, and $q_2 = \chi^2_{(1+\gamma)/2}(n)$ and simplifying we have:

$$P\left[\sum(X_i-\mu)^2/q_2 < \sigma^2 < \sum(X_i-\mu)^2/q_1\right] = \gamma, \text{ or}$$

$$(l,u) = (\sum x_i^2 - n\mu^2)(1/q_2\ ,\ 1/q_1).$$

5. <u>C.I. for Normal σ^2 with μ Unknown</u> [Ref. 1: p. 382; Ref. 3: p. 277]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $(n-1)s^2/\sigma^2$, which is distributed $\chi^2(n-1)$, as the pivotal-quantity, a 100γ% equal tails C.I. is constructed thus:

$$P\left[\chi^2_{(1-\gamma)/2}(n-1) < (n-1)s^2/\sigma^2 < \chi^2_{(1+\gamma)/2}(n-1)\right] = \gamma.$$

Substituting $q_1 = \chi^2_{(1-\gamma)/2}(n-1)$, and $q_2 = \chi^2_{(1+\gamma)/2}(n-1)$ and simplifying we have:

$$P\left[(n-1)s^2/q_2 < \sigma^2 < (n-1)s^2/q_1\right] = \gamma, \text{ or}$$

$$(1,u) = (n-1)s^2(1/q_2\ ,\ 1/q_1).$$

6. <u>C.I. for Exponential λ or μ</u> [Ref. 3: p. 279]

Assuming that $X_1, X_2, \ldots X_n$ are exponential random variables with parameter λ and using $2\lambda n\bar{X}$, which is distributed $\chi^2(2n)$, as the pivotal-quantity, a $100\gamma\%$ equal tails C.I. is constructed thus:

$$P\left[\chi^2_{(1-\gamma)/2}(2n)/2n\bar{X} < 2\lambda n\bar{X} < \chi^2_{(1+\gamma)/2}(2n)\right] = \gamma.$$

Simplifying we have:

$$P\left[\chi^2_{(1-\gamma)/2}(2n)/2n\bar{X} < \lambda < \chi^2_{(1+\gamma)/2}(2n)/2n\bar{X}\right] = \gamma, \text{ or}$$

$$(1,u) = (\chi^2_{(1-\gamma)/2}(2n)/2n\bar{x}\ ,\ \chi^2_{(1+\gamma)/2}(2n)/2n\bar{x}).$$

The C.I. for the mean time to failure ($\mu = 1/\lambda$) is constructed by inverting the above interval to yield:

$$(1,u) = (2n\bar{x}/\chi^2_{(1+\gamma)/2}(2n)\ ,\ 2n\bar{x}/\chi^2_{(1-\gamma)/2}(2n))$$

[Ref. 4: p. 382].

B. THEORY FOR TWO-POPULATION CONFIDENCE INTERVAL ESTIMATION

The confidence interval estimates for two-population situations are discussed here in the same order as they appear in the User Guide for Program 2 (Appendix A). All of these estimates use the pivotal-quantity method discussed earlier [Ref. 1: pp. 379-389]. As in the one-population case above, the C.I. given by (l,u) represents the formula used to calculate the interval estimate.

1. C.I. For Bernoulli $p_X - p_Y$ for Large m and n [Ref. 2: p. 249]

Large m and n means np_X, mp_Y, $n(1-p_X)$, and $m(1-p_Y)$ all greater than five. With this condition met and assuming that X and Y are independent and normally distributed,

$$\frac{(\overline{X} - \overline{Y}) - (p_X - p_Y)}{\sqrt{s_X^2/n + s_Y^2/m}} ,$$

which is distributed approximately N(0,1), is used as the pivotal-quantity. A $100\gamma\%$ C.I. is constructed thus:

$$P\left[-z_{(1+\gamma)/2} < \frac{(\overline{X} - \overline{Y}) - (p_X - p_Y)}{\sqrt{\overline{X}(1-\overline{X})/n + \overline{Y}(1-\overline{Y})/m}} < z_{(1+\gamma)/2}\right] = \gamma .$$

Substituting $c = \sqrt{\overline{X}(1-\overline{X})/n + \overline{Y}(1-\overline{Y})/m}$, and simplifying yields:

$$P\left[\overline{X} - \overline{Y} - cz_{(1+\gamma)/2} < p_X - p_Y < \overline{X} - \overline{Y} + cz_{(1+\gamma)/2}\right] = \gamma, \text{ or}$$

$$(l,u) = (\bar{x} - \bar{y} - cz_{(1+\gamma)/2}\ ,\ \bar{x} - \bar{y} + cz_{(1+\gamma)/2}).$$

2. C.I. for Normal $\mu_X - \mu_Y$ for X and Y Paired [Ref. 2: p. 123]

Assuming that X and Y are normally distributed and letting $\bar{D} = \bar{X} - \bar{Y}$, and using $(\bar{D} - \mu_D)/(S_D/\sqrt{n})$, which is distributed $t(n-1)$, as the pivotal-quantity, a 100γ% C.I. is constructed thus:

$$P\left[t_{(1-\gamma)/2}(n-1) < (\bar{D} - \mu_D)/S_D/\sqrt{n}) < t_{(1+\gamma)/2}(n-1)\right] = \gamma.$$

Substituting $\mu_D = \mu_X - \mu_Y$, and $t = t_{(1+\gamma)/2}(n-1) = -t_{(1-\gamma)/2}(n-1)$ and simplifying yields:

$$P\left[\bar{D} - tS_D/\sqrt{n} < \mu_X - \mu_Y < \bar{D} + tS_D/\sqrt{n}\right] = \gamma \qquad \text{, or}$$

$$(l,u) = (\bar{d} - ts_D/\sqrt{n}, \bar{d} + ts_D/\sqrt{n}), \text{ where } s_D = \frac{\sum d_i^{\,2} - (\sum d_i)^2/n}{(n-1)}$$

and $d_i = x_i - y_i$.

3. C.I. for Normal $\mu_X - \mu_Y$ with $\sigma_X^{\,2} = \sigma_Y^{\,2} = \sigma^2$ [Ref. 2: p. 123]

Assuming that X and Y are independent and using

$$\frac{(\bar{X} - \bar{Y}) - (\mu_X - \mu_Y)}{(1/m + 1/n)S_p^2}$$, which is distributed $t(m+n-2)$,

as the pivotal-quantity. Here and elsewhere in this paper, n and m represent the number of data points in X and Y, respectively. A $100\gamma\%$ C.I. is constructed thus:

$$P\left[t_{(1-\gamma)/2}(m+n-2) < \frac{(\bar{X}-\bar{Y}) - (\mu_X - \mu_Y)}{(1/m + 1/n)S_p^2} < t_{(1+\gamma)/2}(m+n-2)\right] = \gamma.$$

Substituting $t = t_{(1+\gamma)/2}(m+n-2) = -t_{(1-\gamma)/2}(m+n-2)$ and simplifying yields:

$$P\left[\bar{X} - \bar{Y} - t\sqrt{(1/m + 1/n)S_p^2} < \mu_X - \mu_Y < \bar{X} - \bar{Y} + t\sqrt{(1/m + 1/n)S_p^2}\right] = \gamma,$$

or $(l,u) = (\bar{x} - \bar{y} - t\sqrt{(1/m + 1/n)s_p^2}\ ,\ \bar{x} - \bar{y} + t\sqrt{(1/m + 1/n)s_p^2})$,

where $s_p^2 = \dfrac{\sum(x_i - \bar{x})^2 + \sum(y_i - \bar{y})^2}{(m + n - 2)}$.

4. C.I. for Normal $\mu_X - \mu_Y$ with σ_X^2 and σ_Y^2 Known [Ref. 2: p. 123]

Assuming X and Y are independent and using

$$\frac{(\bar{X} - \bar{Y}) - (\mu_X - \mu_Y)}{\sqrt{\sigma_X^2/n + \sigma_Y^2/m}}$$, which is distributed $N(0,1)$, as

the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P\left[-z_{(1+\gamma)/2} < \frac{(\bar{X}-\bar{Y})-(\mu_X-\mu_Y)}{\sqrt{\sigma_X^2/n+\sigma_Y^2/m}} < z_{(1+\gamma)/2}\right] = \gamma.$$

Substituting $z = z_{(1+\gamma)/2} = -z_{(1-\gamma)/2}$ and simplifying we have:

$$P\left[\bar{X}-\bar{Y}-z\sqrt{\sigma_X^2/n+\sigma_Y^2/m} < \mu_X-\mu_Y < \bar{X}-\bar{Y}+z\sqrt{\sigma_X^2/n+\sigma_Y^2/m}\right]=\gamma,$$

or $(l,u) = (\bar{x}-\bar{y}-z\sqrt{\sigma_X^2/n+\sigma_Y^2/m},\ \bar{x}-\bar{y}+z\sqrt{\sigma_X^2/n+\sigma_Y^2/m})$.

5. C.I. for Normal σ_X^2/σ_Y^2 [Ref. 4: p. 464]

Assuming X and Y are independent and using $(S_Y^2/\sigma_Y^2)/(S_X^2/\sigma_X^2)$, which is distributed $F(m-1,n-1)$, as the pivotal-quantity, a 100γ% C.I. is constructed thus:

$$P\left[F_{(1-\gamma)/2}(m-1,n-1) < \frac{S_Y^2/\sigma_Y^2}{S_X^2/\sigma_X^2} < F_{(1+\gamma)/2}(m-1,n-1)\right] = \gamma.$$

Substituting $F_{(1-\gamma)/2}(m-1,n-1) = \dfrac{1}{F_{(1+\gamma)/2}(n-1,m-1)}$, and simplifying we have:

$$P\left[\frac{S_X^2/S_Y^2}{F_{(1+\gamma)/2}(n-1,m-1)} < \frac{\sigma_X^2}{\sigma_Y^2} < (S_X^2/S_Y^2)F_{(1+\gamma)/2}(m-1,n-1)\right] = \gamma.$$

$$\text{or } (l,u) = \left(\frac{s_X^2/s_Y^2}{F_{(1+\gamma)/2}(n-1,m-1)},\ (s_X^2/s_Y^2)F_{(1+\gamma)/2}(m-1,n-1)\right).$$

6. C.I. for Exponential $\lambda_X/\lambda_Y = \mu_Y/\mu_X$ [Ref. 4: p. 466]

Assuming X and Y are independent and using $\bar{X}\lambda_X/\bar{Y}\lambda_Y$, which is distributed F(2n,2m), as the pivotal-quantity, a 100γ% C.I. is constructed thus:

$$P\left[F_{(1-\gamma)/2}(2n,2m) < \bar{X}\lambda_X/\bar{Y}\lambda_Y < F_{(1+\gamma)/2}(2n,2m)\right] = \gamma.$$

Simplifying we have:

$$P\left[(\bar{Y}/\bar{X})F_{(1-\gamma)/2}(2n,2m) < \lambda_X/\lambda_Y < (\bar{Y}/\bar{X})F_{(1+\gamma)/2}(2n,2m)\right] = \gamma.$$

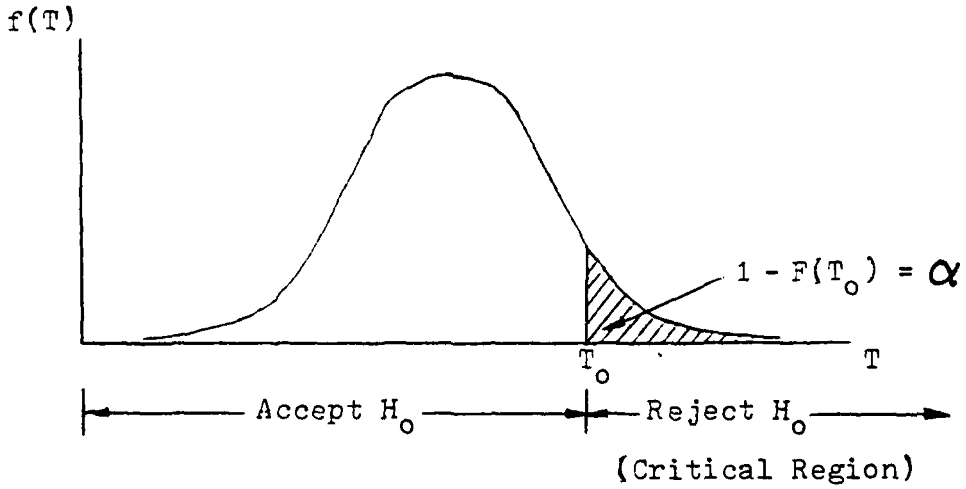
$$\text{or } (l,u) = \left((\bar{Y}/\bar{X})F_{(1-\gamma)/2}(2n,2m),\ (\bar{Y}/\bar{X})F_{(1+\gamma)/2}(2n,2m)\right).$$

C. THEORY FOR ONE-POPULATION HYPOTHESIS TESTS

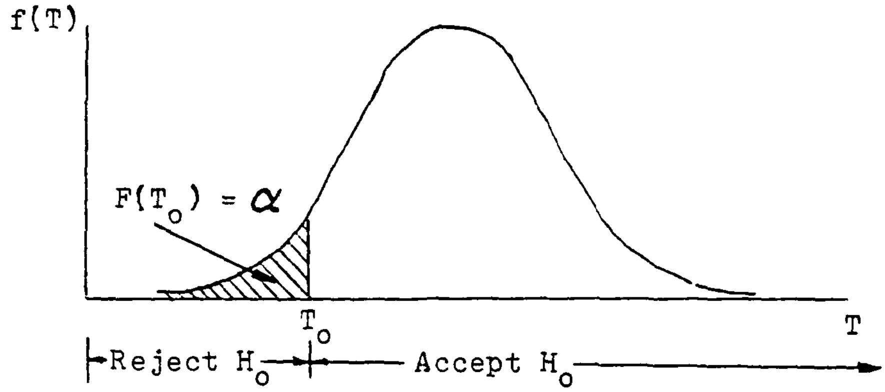
Three types of hypothesis tests are performed in Program 3; these are upper-tailed, lower-tailed and two-tailed tests. The general procedure used for all three tests is the same. Basically, a test statistic T, which has an assumed distribution, is computed with user-supplied data and then compared to a critical region defined by T_o. This T_o value is determined by the type of test, the assumed distribution, and the user-supplied α value. For two-tailed tests there are actually two values of T_o used; these values will be denoted here by T_1 and T_2. In performing the test then, if the test statistic T is outside the critical region, then we accept our original hypothesis H_o; otherwise, we reject H_o and accept the alternative H_1.

The following graphs illustrate the three types of tests discussed. These graphs represent a probability density function, f(T), where the shaded area under each curve represents values from a corresponding cumulative distribution function, F(T).

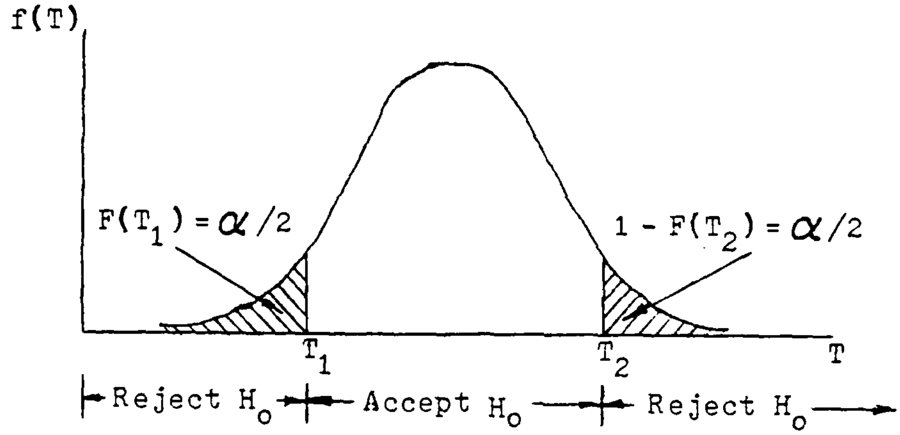
Upper-Tailed Test



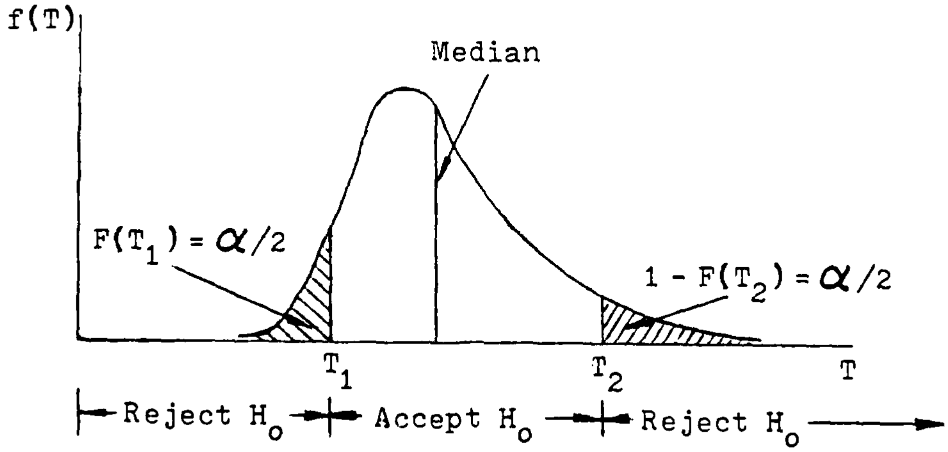
Lower-Tailed Test



Two-Tailed Test for Symmetric Distributions (Normal, t)



Two-Tailed Test for Unsymmetric Distributions (Chi-Square, F)



An upper-tailed test is performed whenever the user enters a +1, choosing the upper-tail alternate hypothesis, during step one of the solution. A lower-tailed test requires the user to enter a -1 during the solution, and a two-tailed test requires a 0 entry. For two-tailed unsymmetric tests the relationship between the test statistic and the median determines which tail is actually used for the test. If the test statistic is greater than the median then the two-tailed test is performed using the upper tail T_0 value. For test statistic values less than the median the test uses the lower tail T_0 value. However, there is no general agreement that a two-tailed test should be performed this way.

The test statistics used in Program 3 will now be listed in the same order in which they appear in the User Guide. This listing will also include a reference where more information concerning a particular subject can be found. Additionally, the assumed distribution for each test statistic will appear with that test statistic.

1. Test Statistic for Normal μ_0 with σ^2 Known [Ref. 1: p. 431]

$$T = \frac{(\bar{x} - \mu_0)\sqrt{n}}{\sigma} \qquad \text{, using } N(0,1)$$

2. Test Statistic for Normal μ_0 with σ^2 Unknown [Ref. 1: p. 431]

$$T = \frac{(\bar{x} - \mu_o)\sqrt{n}}{s_X}, \qquad \text{using } N(0,1) \text{ for } n > 30, \text{ and } t(n-1) \text{ for } n < 30$$

3. <u>Test Statistic for Bernoulli P_o</u> [Ref. 2: p. 101]

For $n > 30$

$$T = \frac{n(p_o - \bar{x})}{\sqrt{n(1 - p_o)p_o}}, \quad \text{using } N(0,1)$$

For $n < 30$ the Binomial Distribution in the Statistics Module is used to directly calculate the appropriate probability for comparison with α.

4. <u>Test Statistic for Normal σ_o^2 with μ Known [Ref. 1: p. 432; Ref. 2: p. 104]</u>

For $n < 65$

$$T = T' = \frac{\sum x_i^2 + n\mu^2 - 2\mu\sum x_i}{\sigma_o^2}, \qquad \text{using } \chi^2(n)$$

For $n > 65$

$$T = \frac{T' - n}{\sqrt{2n}}, \qquad \text{using } N(0,1)$$

5. <u>Test Statistic for Normal σ_o^2 with μ Unknown [Ref. 1: p. 432; Ref. 2, p. 104]</u>

For $n < 64$

$$T = T' = \frac{(n-1)s_X^2}{\sigma_o^2} \quad , \qquad \text{using } \chi^2(n-1)$$

For n > 64

$$T = \frac{T' - (n-1)}{\sqrt{2(n-1)}} \quad , \qquad \text{using } N(0,1)$$

6. <u>Test Statistic for Exponential $\mu_o = 1/\lambda_o$</u> [Ref. 3: p. 279]

For n < 32

$$T = T' = \frac{2n\bar{x}}{\mu_o} \quad , \qquad \text{using } \chi^2(2n)$$

For n > 32

$$T = \frac{T' - 2n}{2\sqrt{n}} \quad , \qquad \text{using } N(0,1)$$

7. <u>Test Statistic for Poisson λ_o</u> [Ref. 2: p. 248]

For n < 30

$$T = n\lambda_o \, , \qquad \text{using } \chi^2(2n\bar{x})$$

For $n > 30$

$$T = \frac{n\bar{x} - n\lambda_o}{\sqrt{n\lambda_o}} \quad , \qquad \text{using } N(0,1)$$

D. THEORY FOR TWO-POPULATION HYPOTHESIS TESTS

The two-population hypothesis tests are performed in the same manner as the one-population tests. For an explanation of these tests, refer to C above. The test statistics used in Program 4 will now be listed in the same order in which they appear in the User Guide. This listing will include the assumed distribution and applicable references.

1. Test Statistic for Bernoulli $P_X = P_Y$ [Ref. 2: p. 249]

$$T = \frac{(\bar{x} - \bar{y})}{\sqrt{\left(1 - \frac{(m\bar{y} + n\bar{x})}{(m + n)}\right)\left(\frac{(m\bar{y} + n\bar{x})}{(m + n)}\right)\left(\frac{1}{n} + \frac{1}{m}\right)}}, \text{ using } N(0,1)$$

2. Test Statistic for Normal $\mu_X = \mu_Y$ for X,Y Paired [Ref. 2: p. 121]

$T = \bar{d}(\sqrt{n}/s_d)$, using $t(n-1)$ for $n < 31$, and $N(0,1)$ for $n \geq 31$

3. Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y Independent with $\sigma_X^2 = \sigma_Y^2$ [Ref. 1: pp. 434-435; Ref. 2: p. 116]

$$T = \frac{\bar{x} - \bar{y}}{s_p\sqrt{\frac{1}{n} + \frac{1}{m}}}, \text{ where } s_p = \sqrt{\frac{(n-1)s_X^2 + (m-1)s_Y^2}{n + m - 2}}$$

and using t(n+m-2) for n < 32, and N(0,1) for $n \geq 32$

4. Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y Independent with σ_X^2, σ_Y^2 Known [Ref. 2: p. 119]

$$T = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{\sigma_X^2}{n} + \frac{\sigma_Y^2}{m}}}$$

, using N(0,1)

5. Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y Independent with $\sigma_X^2 \neq \sigma_Y^2$ [Ref. 2: p. 119]

$$T = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{s_X^2}{n} + \frac{s_Y^2}{m}}}$$

, using N(0,1) for $df \geq 30$, and t(df) for df < 30, where

$$df = \text{largest integer in}\left(\frac{\left(\frac{s_X^2}{n}+\frac{s_Y^2}{m}\right)^2}{\frac{\left(\frac{s_X^2}{n}\right)^2}{n}+\frac{\left(\frac{s_Y^2}{m}\right)^2}{m}} - 1.5\right)$$

6. <u>Test Statistic for Normal $\sigma_X^2 = \sigma_Y^2$ for X and Y Independent</u> [Ref. 2: p. 111]

$$T = \frac{s_x^2}{s_y^2}, \text{ using } F(n-1,m-1)$$

7. <u>Test Statistic for Normal $\rho = 0$</u> [Ref. 1: pp. 492-493; Ref. 2: p. 200]

$$T = r\sqrt{\frac{(n-2)}{1-r^2}}, \text{ using } t(n-2) \text{ for } n < 28, \text{ and } N(0,1) \text{ for } n \geq 28$$

8. <u>Test Statistic for Exponential $\lambda_X = \lambda_Y$ for X and Y Independent</u> [Ref. 4: p. 310]

$$T = \frac{\bar{x}}{\bar{y}}, \text{ using } F(2n,2m)$$

E. THEORY FOR METHODS OF APPROXIMATION

The methods used to approximate distribution values for this package of programs come from many sources, and any complete discussion of the theory involved would be beyond the scope of this paper. Therefore, while every method which has been used will be referenced, only those methods unique to this programming effort will be discussed in theoretical detail. With this in mind, a combination listing and discussion will follow which will trace the approximation methods used in this paper. The approximations unique to this effort are the inverse cumulative distribution functions (CDF) for the Chi-Square, Student's t and F distributions as well as the Multinomial approximation. The inverse Normal CDF approximation discussed here was used in Professor Zhena's programs. All other approximations used in this paper are modifications of methods from the TI-59 Statistics Module. For a better discussion of the exact methods used in these cases, the TI-59 Applied Statistics Manual should be consulted [Ref. 7].

There are two types of inverse CDF approximations used in this paper. The first two programs use a less accurate Type I approximation, while the distribution programs use a closely related, but more accurate, Type II approximation. What follows is a discussion of the methods used for approximating the inverse Normal, Chi-Square, Student's t and F distrubitons, and the Multinomial distribution.

1. Inverse Normal CDF Approximation [Ref. 5: p. 933]

a. Type I Approximation

This approximation is used in Programs 1 and 2 for inverse Normal CDF values and as a subroutine for the Chi-Square, t and F approximations in those same programs. The Type I approximation uses the following set of equations and constants to approximate inverse Normal CDF values, given the input probability p. Programs 1 and 2 have the limitation that p be greater than .5.

$$Z_p = t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \text{ , where } t = \sqrt{\ln(1/(1-p)^2)} \text{ , and}$$

$$c_0 = 2.515517 \qquad d_1 = 1.432788$$
$$c_1 = .802853 \qquad d_2 = .189269$$
$$c_2 = .010328 \qquad d_3 = .001308$$

b. Type II Approximation

The Type II approximation is almost identical to the Type I approximation. The only difference is the addition of a function which removes the limitation that p be greater than .5. This function uses the symmetric quality of the Normal distribution and returns the negative of the approximation for 1-p, whenever p is less than .5.

2. Inverse Chi-Square CDF Approximation [Ref. 5: p. 941]

a. Type I Approximation

This approximation is used in Program 1 only and uses the inverse Normal CDF approximation described above. The inverse Chi-Square CDF approximation uses the following set of equations and calculates both $\chi^2_{(1-p)}(v)$ and $\chi^2_{(p)}(v)$ given the input probability p. The reference listed above limits degrees of freedom, v, for this approximation to values above 30; however, as can be seen in Appendix B values well below v = 30 produce acceptable approximations.

$$\chi^2_p(v) = v(1 - a + z_p\, a)^3 \ , \text{ where } a = \frac{2}{9v}$$

b. Type II Approximation

This approximation is used only in Program 7 and incorporates the Type I inverse Chi-Square CDF approximation with an Accuracy Enhancing Technique (AET) which requires the highly accurate forward Chi-Square CDF approximation contained in that same program. This AET involves taking the output of the Type I approximation and using it in the forward CDF approximation to obtain an estimate, $\hat{p}$, of the actual probability achieved by the Type I approximation. This estimate is then used to correct the inverse approximation input, p, for any difference between desired and actual probability. The corrected inverse input, p', is computed using the following formula:

$$p' = p + (p - \hat{p}) \ .$$

By using p' as the new input for the inverse CDF approximation, a more accurate approximation is achieved (see Appendix B). This AET is not used for $v > 30$ since the Type I approximation is then quite accurate.

3. Inverse Student's t CDF Approximation

a. Type I Approximation

This approximation is used in Programs 1, 2, 8 and 9 and requires the inverse Normal CDF approximation already described. The following equation represents one of several approximations to the inverse t developed by Professor Donald P. Gaver, Naval Postgraduate School. This approximation is limited to values of $v \geq 2$ [Ref. 8].

$$t_p(v) = Z_p\left(1 + Z_p^{\,2}\left(\frac{-1 + \sqrt{1 + \frac{10}{3(v - 1.57)}}}{5}\right)\right), \quad v \geq 2$$

b. Type II Approximation

This approximation is used only in Program 8 and, like the Type II Chi-Square approximation, uses an AET to increase the accuracy of the Type I approximation. The procedures for this AET are exactly the same as in the Chi-Square approximation. Additionally, the restriction on v has been removed by using the following relationship to generate inverse approximations when $v = 1$.

$$t_p(1) = \frac{1}{\tan(1-p)}$$, where for $p < .5$, $2p$ is used in place of p

4. Inverse F CDF Approximation [Ref. 5: p. 947]

a. Type I Approximation

This approximation is used in Programs 1 and 2 and uses the inverse Normal approximation discussed earlier. The following set of equations is used to generate the approximation:

$$F_p(v_1,v_2) = e^{2w} \text{ , where } w = \frac{Z_p\sqrt{(h + k)}}{h} \text{ , } k = \frac{Z_p^{\ 2} - 3}{6} \text{ ,}$$

$$h = \frac{1}{2(1/(v_1 - 1) + 1/(v_2 - 1))} \text{, and } v_1 \neq 1, \ v_2 \neq 1$$

b. Type II Approximation

This approximation uses the AET discussed earlier along with two more techniques to provide inverse approximations for all values of v_1 and v_2. For the case where v_1 or $v_2 = 1$, the Type I inverse t approximation discussed earlier is used in the following relationships to generate the required inverse F CDF approximations:

$$F_p(1,v) = (t_{(1+p)/2}(v))^2 \quad \text{, or equivalently}$$

$$F_p(v,1) = \left(\frac{1}{t_{(1+p)/2}(v)}\right)^2 .$$

For the case where $v_1 = v_2 = 1$, the following relationship is used:

$$F_p(1,1) = \frac{1}{\tan(1-p)} .$$

5. Multinomial Approximation

The method used to generate multinomial density values is not truly unique; however, it uses the following equation in a way that minimizes rounding errors:

$$f_N(n_1, n_2, \ldots, n_k) = \frac{N!}{(n_1!)(n_2!)\ldots(n_k!)}(p_1{}^{n_1})(p_2{}^{n_2})\ldots(p_k{}^{n_k}).$$

Computations are accomplished in the following order to avoid, as much as possible, multiplying extremely small values by extremely large values:

$$\left(\frac{N(p_1{}^{n_1})}{n_1!}\right)\left(\frac{(N-1)(p_2{}^{n_2})}{n_2!}\right)\cdots\left(\frac{(N-k)(p_k{}^{n_k})}{n_k!}\right)(N-k-1)!\ .$$

IV. TI-59

The choice of the TI-59 as the calculator for this programming effort was based on two factors. Professor Zehna's original programs were written for the TI-59; and each student in the Operations Research (OR) curriculum is issued a TI-59 for use in basic probability and statistics courses. In general, the use of hand-held programmable calculators has been shown [Ref. 6: p. 1] to increase student learning and capability. Further, it is intended that the programs described in this paper will be used by OR students in their coursework.

Using the TI-59 offered some disadvantages and some advantages in developing the programming package presented here. The disadvantages of limited storage, slow computation time and awkward data entry sequence are discussed elsewhere in this paper. There are two advantages of the TI-59, however, that deserve noting here. The programming steps and procedures used in the TI-59 are easily learned and logical. This ease of programming makes complex computational methods easy to program. Another advantage of the TI-59 is its compatibility with the PC-100C printer. Using the printer/calculator combination greatly simplifies writing, editing, and error diagnosis. These advantages of the TI-59 make programming relatively easy and also allow the capabilities of the TI-59 to be used more fully.

V. ALTERNATE SOLUTIONS

The problems presented in this paper could have been solved in any number of equally valid ways. This section will briefly discuss the specific alternatives which could increase the capability of the solutions employed here. This discussion will first focus on alternative hardware which could be used, and then on program changes which might be made.

A. HARDWARE ALTERNATIVES

As discussed earlier, the use of the TI-59 calculator is appropriate for this programming package; however, the methods and techniques used in this paper are equally suited to other programmable calculators or computers. Indeed, the use of any other calculator or computer with more storage capability than the TI-59 might be a better vehicle for the package of programs presented here. These programs require a total of 14 magnetic cards (22 separate sides) using the TI-59. Current console model computers could easily store all of these programs at the same time.

The TI-59 has the ability to use program modules, and the nine programs from this package could easily be combined to form the basis of a new module. By careful elimination of redundant functions, such a module could also accommodate an ANOVA and/or regression package. A module of this type might find widespread acceptance, especially in the classroom.

B. PROGRAMMING ALTERNATIVES

The choice of distribution approximating methods used here and the general layout of the entire package might both be improved with some additional effort. The methods of approximation used here were chosen rather arbitrarily. It is possible that more appropriate methods of approximation exist. More appropriate methods might include methods with fewer program steps and equal accuracy, as well as methods which take less computation time with equal accuracy.

The current layout of the nine programs in this package might be improved by reducing the number of programs. The present program size precludes this; however, by eliminating some program functions, it might be possible to organize all of the inverse CDF approximations in one program. Shorter approximating methods might make possible a similar program, but with both inverse CDF and regular CDF approximations.

The extensive user guides with their sample problems are useful for students, but could prove awkward for a more experienced user. An obvious alternative would be a shortened user guide directed at those more familiar with the programs.

VI. CONCLUSION

Two problems were presented for solution in this paper. One problem involved expanding and modifying an existing set of TI-59 programs into a user-friendly package. A second problem involved developing a set of distribution approximating programs. The solution to the first problem incorporated increased capability, standardized data entry, and detailed user guides into a package of nine programs. The first priority in this solution was providing a format compatible with a student's needs while maintaining the capability required by a more experienced user. The TI-59 calculator proved to be a very useful tool in this solution, and demonstrated the generally unused capability of the current generation of hand-held programmable calculators.

The approximation programs presented as a solution to the second problem mentioned above provide accurate and comprehensive approximations. These programs practically eliminate the need for tables of values and solve the interpolation problem present in all such tables.

Together these two solutions represent a package with considerable capability in computing confidence intervals, performing hypothesis tests, and generating approximate distribution values. A comprehensive set of user guides makes this same capability available even to inexperienced users. The methods used in preparing this TI-59 programming package are directly applicable to other calculators or computers.

APPENDIX A

PROGRAM 1 USER GUIDE - One-Population Confidence Intervals

INTRODUCTION: The purpose of this program is to compute $100\gamma\%$ confidence intervals (l,u) or bounds [l and u] for the following one-population situations:

NORMAL	μ with σ^2 known
NORMAL	μ with σ^2 unknown
BERNOULLI	p
NORMAL	σ^2 with μ known
NORMAL	σ^2 with μ unknown
EXPONENTIAL	λ or μ .

The routines in this program require percentiles from either the Normal, Chi-Square, Student's t or F distributions. Each routine will automatically generate an approximate percentile; however, when additional accuracy is desired or small sample sizes are involved the use of percentile values from either standard tables or the distribution approximating programs is recommended. In step two of each routine the user can choose to accept the approximate percentile, by storing the appropriate percentage in storage register 09 (R_{09}), or he can store the percentile value in R_{11}. Some routines also require percentile values in R_{13}.

GENERAL PROCEDURES:

1. Use any library module, and after reading all three card sides, press $\boxed{D}$ to repartition (639.39).

2. For data entry press $\boxed{D}$ followed by data point x_i, $\boxed{R/S}$, x_i, $\boxed{R/S}$, etc. for each x_i ($i=1,2,\ldots,n$) until all points have been

entered. Mistakes in data entry should be corrected immediately by reentering the unwanted point and pressing $\boxed{\text{INV}}$ $\boxed{\text{2nd}}$ $\boxed{\Sigma+}$, then enter the correct data point and press $\boxed{\text{R/S}}$ $\boxed{\text{R/S}}$. Alternate data entry using summary statistics is detailed in applicable routines.

3. For one-sided confidence bounds rather than intervals replace $(1+\gamma)/2$ with γ and $(1-\gamma)/2$ with $1-\gamma$ everywhere they appear (e.g. $z_{(1+\gamma)/2}$ becomes z_γ) and proceed as usual, ignoring l or u as appropriate.

4. When solving consecutive problems, care should be taken to clear all previously used registers. Pressing $\boxed{\text{D}}$ will clear all registers.

<u>PROGRAM 1 SPECIFIC PROCEDURES</u>:

<u>C.I. For NORMAL μ with σ^2 known</u>

1. Enter data using $\boxed{\text{D}}$ and store σ in R_{07} (Alternate entry: store n in R_{03}, $\bar{x}$ in R_{08} and σ in R_{07})
2. Store <u>either</u> $(1+\gamma)/2$ in R_{09} <u>OR</u> $z_{(1+\gamma)/2}$ in R_{11}
3. Press $\boxed{\text{A}}$ l is displayed, then press $\boxed{x \gtrless t}$ u is displayed

<u>C.I. For NORMAL μ with σ^2 unknown</u>

1. Enter data using $\boxed{\text{D}}$ (Alternate entry: store n in R_{03}, s in R_{07} and $\bar{x}$ in R_{08})
2. Store <u>either</u> $(1+\gamma)/2$ in R_{09} <u>OR</u> $t_{(1+\gamma)/2}(n-1)$ in R_{11}
3. Press $\boxed{\text{C}}$ l is displayed, then press $\boxed{x \gtrless t}$ u is displayed

C.I. For BERNOULLI p

1. Store $n\bar{x}$ in R_{01} and n in R_{03}
2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}(2n\bar{x}+2, 2n-2n\bar{x})$ in R_{11}

   AND

   $F_{(1+\gamma)/2}(2n-2n\bar{x}+2, 2n\bar{x})$ in R_{13}
3. Press $\boxed{B}$ l is displayed, then

   press $\boxed{x \gtrless t}$ u is displayed

C.I. For NORMAL σ^2 with μ known

1. Enter data using $\boxed{D}$ and store μ in R_{08} (Alternate entry: store $\sum x_i^2$ in R_{02}, n in R_{03} and μ in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(n)$ in R_{11}

   AND

   $\chi^2_{(1+\gamma)/2}(n)$ in R_{13}
3. Press $\boxed{C'}$ l is displayed, then

   press $\boxed{x \gtrless t}$ u is displayed

C.I. For NORMAL ^{2} with unknown

1. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03} and $(n-1)s^2$ in R_{12})
2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(n-1)$ in R_{11}

   AND

   $\chi^2_{(1+\gamma)/2}(n-1)$ in R_{13}
3. Press $\boxed{D'}$ l is displayed, then

   press $\boxed{x \gtrless t}$ u is displayed

C.I. For EXPONENTIAL λ or μ *

1. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03} and $\bar{x}$ in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(2n)$ in R_{11}

   AND

   $\chi^2_{(1+\gamma)/2}(2n)$ in R_{13}
3. Press $\boxed{E}$ l is displayed, then

   press $\boxed{x \rightleftarrows t}$ u is displayed

* 4. To compute a confidence interval or bound for $\mu = 1/\lambda$ press $\boxed{E'}$ rather than $\boxed{E}$ above.

PROGRAM 1 ADDITIONAL CAPABILITIES:

Inverse Normal CDF Approximation

1. Store p in R_{09} ($p > .5$)
2. Press $\boxed{B'}$ z_p is displayed, and

   $z_{(1-p)}$ is available in R_{13}

Inverse Chi-Square CDF Approximation

1. Store p in R_{09} ($p > .5$), and store v in R_{14} ($v \neq 1$)
2. Press $\boxed{SBR}$ $\boxed{X^2}$ $\chi^2_p(v)$ is displayed, and

   $\chi^2_{(1-p)}(v)$ is available in R_{11}

Inverse F CDF Approximation

1. Store p in R_{09} ($p > .5$), v_1 in R_{20} and v_2 in R_{21} ($v_1 \neq 1, v_2 \neq 1$)
2. Press $\boxed{SBR}$ $\boxed{RCL}$ $F_p(v_1, v_2)$ is displayed

Inverse Student's t CDF Approximation

1. Store p in R_{09} ($p > .5$) and v in R_{19} ($v \neq 1$)
2. Press $\boxed{SBR}$ $\boxed{STO}$ $t_p(v)$ is displayed

PROGRAM 1 LABELS USED:

A	A'	SBR	RCL
B	B'	GTO	STO
C	C'	$x \gtrless t$	
D	D'	X^2	
E	E'	=	

PROGRAM 1 STORAGE REGISTER CONTENTS:

00	clear	15	used
01	$\sum x$	16	clear
02	$\sum x_i^2$	17	clear
03	n	18	clear
04	used	19	v
05	clear	20	v_1
06	clear	21	v_2
07	s or σ	22	clear
08	$\bar{x}$ or μ	23	clear
09	$(1+\gamma)/2$ or p	24	used
10	used	25	clear
11	CDF value	26	clear
12	$(n-1)s^2$	27	used
13	CDF value	28	used
14	v	29-49	clear

PROGRAM 1 SAMPLE PROBLEMS:

1. Suppose $\bar{x} = 69.7$, $n = 8$, $\sigma^2 = 3.5$. Find a 90% C.I. for estimating the mean.

SOLUTION:

(1) Store n=8 in R_{03}, $\bar{x} = 69.7$ in R_{08} and $\sigma = \sqrt{3.5}$ in R_{07}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $z_{.95} = 1.645$ in R_{11}

(3) Press $\boxed{A}$ then $\boxed{x \gtrless t}$ to display

l = 68.61179492	OR	l = 68.61193477
u = 70.78820508		u = 70.78806523

2. Given the following observations from a population with a known variance of 15, find a lower 99% confidence bound on the mean.

165 178 160 199 167 145 157 182 192 165

SOLUTION:

(1) Enter data using $\boxed{D}$ sequence and store $\sigma = \sqrt{15}$ in R_{07}

(2) Store $\gamma = .99$ in R_{09} OR $z_{.99} = 2.326$ in R_{11}

(3) Press $\boxed{A}$ then $\boxed{x \gtrless t}$ to display

l = 168.1502816	OR	l = 168.1512434
ignore u		ignore u

3. Find a 90% C.I. for the mean of the following test scores.

35 34 46 20 38 39 32 49 41 25 18 43 51 38 42 29 59 53 27 33

SOLUTION:

(1) Enter data using $\boxed{D}$ sequence

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $t_{.95}(19) = 1.729$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

l = 33.39962583	OR	l = 33.39390952
u = 41.80037417		u = 41.80609048

4. Find a 95% upper confidence bound for μ given the following information: $n = 55$, $s = 15$ and $\bar{x} = 85$.

SOLUTION:

(1) Store $n = 55$ in R_{03}, $s = 15$ in R_{07} and $\bar{x} = 85$ in R_{08}

(2) Store $\gamma = .95$ in R_{09} OR $t_{.95}(54) = 1.673$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

ignore l	OR	ignore l
u = 88.38398464		u = 88.38380911

5. Of 1000 people treated with a certain drug 200 showed a reaction. Find a 90% C.I. for the proportion of the sample population that will show a reaction.

SOLUTION:

(1) Press $\boxed{D}$ then store $n\bar{x} = 200$ in R_{01} and $n = 1000$ in R_{03}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(402,1600) = 1.13$ in R_{11}

AND

$F_{.95}(1602,400) = 1.14$ in R_{13}

(3) Press $\boxed{B}$ then $\boxed{x \gtrless t}$ to display

l = .1793622306	OR	l = .1796719191
u = .2219574577		u = .2211307235

6. Find a 95% upper confidence bound for the proportion of the sample population if nine of 24 treated were affected.

SOLUTION:

(1) Press $\boxed{D}$ then store $n\bar{x} = 9$ in R_{01} and $n = 24$ in R_{03}

(2) Store $\gamma = .95$ in R_{09} OR $F_{.95}(20,30) = 1.93$ in R_{11}

AND

$F_{.95}(32,18) = 2.13$ in R_{13}

(3) Press $\boxed{B}$ then $\boxed{x \gtrless t}$ to display

ignore 1	OR	ignore 1
u = .5629409878		u = .5626822157

7. Find a 95% C.I. for σ^2 and for σ given the following observations from a sample population with $\mu = 65.0$.

100 15 73 46 65 98 79 38 68 85

SOLUTION:

(1) Enter data using $\boxed{D}$ and store $\mu = 65$ in R_{08}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(10) = 3.25$ in R_{11}

AND

$\chi^2_{.975}(10) = 20.48$ in R_{13}

(3) Press $\boxed{C'}$ then $\boxed{x \gtrless t}$ to display (for σ^2)

l = 428.7608301	OR	l = 428.8574219
u = 2726.124604		u = 2702.461538

Taking square roots the following limits for σ are displayed

l = 20.70654076	OR	l = 20.70887302
u = 52.21230319		u = 51.985205

8. Suppose $n = 15$, $\sum x_i^2 = 88476$ and $\mu = 30.5$. Find a 97.5% upper confidence bound on the standard deviation.

SOLUTION:

(1) Press $\boxed{D}$ then store $\sum x_i^2 = 88476$ in R_{02}, $n = 15$ in R_{03} and $\mu = 30.5$ in R_{08}

(2) Store $\gamma = .975$ in R_{09} OR $\chi^2_{.025}(15) = 6.26$ in R_{11}

AND

$\chi^2_{.975}(15) = 27.49$ in R_{13}

(3) Press $\boxed{C'}$ then $\boxed{x \gtrless t}$ and take square root to display

ignore 1	OR	ignore 1
u = 109.2668647		u = 109.1078035

9. Find a 95% C.I. for σ given the following observations.

100 15 73 46 65 98 79 38 68 85

SOLUTION:

(1) Enter data using $\boxed{D}$

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(9) = 2.70$ in R_{11}

AND

$\chi^2_{.975}(9) = 19.02$ in R_{13}

(3) Press $\boxed{D'}$ then $\boxed{x \gtrless t}$, and take square roots to display

l = 18.54742	OR	l = 18.54896609
u = 49.47192697		u = 49.23150151

10. Suppose n = 45 and s^2 = 36 find a 90% lower confidence bound for σ^2.

SOLUTION:

(1) Press $\boxed{D}$ then store n = 45 in R_{03} and $(n-1)s^2 = 1584$ in R_{12}

(2) Store $\gamma = .90$ in R_{09} OR $\chi^2_{.10}(44) = 32.5$ in R_{11} AND $\chi^2_{.90}(44) = 56.4$ in R_{13}

(3) Press $\boxed{D'}$ to display

l = 28.10395538 ignore u OR l = 28.08510638 ignore u

11. Given the time to failure of an electron tube is an exponential random variable, and the sum of 25 times to failure is 25242. Find a 95% C.I. for λ.

SOLUTION:

(1) Press $\boxed{D}$ then store n = 25 in R_{03} and $\bar{x} = 25242/25$ in R_{08}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(50) = 31.92$ in R_{11} AND $\chi^2_{.975}(50) = 70.92$ in R_{13}

(3) Press $\boxed{E}$ then $\boxed{x \gtrless t}$ to display

l = .0006407042 u = .001414878 OR l = .0006322795 u = .0014048015

12. Six expensive pieces of equipment had the following times to failure. Find a 95% C.I. for the mean time to failure.

233.6 3119.0 258.3 1402.7 612.9 2211.2

<u>SOLUTION:</u>

(1) Enter data using $\boxed{\text{D}}$

(2) Store $(1+\gamma)/2 = .975$ in R_{09} <u>OR</u> $\chi^2_{.025}(12) = 4.40$ in R_{11}

<u>AND</u>

$\chi^2_{.975}(12) = 23.34$ in R_{13}

(3) Press $\boxed{\text{E'}}$ then $\boxed{x \rightleftarrows t}$ to display

l = 671.6219738 <u>OR</u> l = 671.6109683

u = 3578.128804 u = 3562.590909

PROGRAM 2 USER GUIDE - Two-Population Confidence intervals:

INTRODUCTION: The purpose of this program is to compute $100\gamma\%$ confidence intervals (l,u) or bounds $[l$ and $u]$ for the following two-population situations.

BERNOULLI	$p_X - p_Y$	for large sample sizes
NORMAL	$\mu_X - \mu_Y$	for X and Y paired with σ^2 unknown
NORMAL	$\mu_X - \mu_Y$	for X and Y independent with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$
NORMAL	$\mu_X - \mu_Y$	for X and Y indep with σ_X^2 and σ_Y^2 known
NORMAL	σ_X^2/σ_Y^2	for X and Y independent
EXPONENTIAL	$\lambda_X/\lambda_Y = \mu_Y/\mu_X$	for X and Y independent

The routines in this program require percentiles from either the Normal, Student's t or F distributions. Each routine will automatically generate an approximate percentile; however, when additional accuracy is desired or small sample sizes are involved the use of percentile values from either standard tables or the distribution approximating programs is recommended. In step two of each routine the user can choose to accept the approximate percentile, by storing the appropriate percentage in R_{09}, or he can store the the percentile value in R_{11}. Some routines also require percentile values in R_{13}.

GENERAL PROCEDURES:

1. Use any library module, and after reading all three card sides, press $\boxed{D}$ to repartition (719.29).

2. Data entry for independent data (DEI Sequence), press $\boxed{D}$ followed by data point x_i, $\boxed{R/S}$, x_{i+1}, $\boxed{R/S}$, etc. for each x_i (i=1,2, ...,n). When all of the x_i's have been entered press $\boxed{D'}$ followed by data point y_i, $\boxed{R/S}$, y_{i+1}, $\boxed{R/S}$, etc. for each y_i (i=1,2,...,m).

When all of the y_i's have been entered press $\boxed{\text{SBR}}$ $\boxed{\text{GTO}}$. Mistakes in data entry should be corrected immediately by reentering the unwanted data point and pressing $\boxed{\text{INV}}$ $\boxed{\text{2nd}}$ $\boxed{\Sigma+}$, then enter the correct data point and press $\boxed{\text{R/S}}$ $\boxed{\text{R/S}}$. Alternate data entry using summary statistics is detailed in applicable routines.

3. Data entry for paired data (DEP Sequence), press $\boxed{\text{D}}$ followed by x_i, $\boxed{x \gtrless t}$, y_i, $\boxed{\text{R/S}}$, x_{i+1}, $\boxed{x \gtrless t}$, y_{i+1}, $\boxed{\text{R/S}}$, etc. for each data pair x_i, y_i $(i=1,2,\ldots,n)$, then press $\boxed{\text{SBR}}$ $\boxed{\text{RST}}$. Mistakes and alternate entry are as above.

4. For confidence bounds rather than intervals, replace $(1+\gamma)/2$ with γ everywhere it appears (e.g. $t_{(1+\gamma)/2}(v)$ becomes $t_{\gamma}(v)$) and proceed as usual ignoring either l or u as appropriate.

5. When solving consecutive problems, care should be taken to clear all previously used storage registers. Pressing $\boxed{\text{D}}$ will clear all registers.

<u>PROGRAM 2 SPECIFIC PROCEDURES</u>:

<u>C.I. For BERNOULLI</u> $p_X - p_Y$ <u>for large sample sizes</u>*

1. Press $\boxed{\text{D}}$ then store $n\bar{x}$ in R_{01}, $m\bar{y}$ in R_{02} n in R_{03}, m in R_{04}
2. Store either $(1+\gamma)/2$ in R_{09} <u>OR</u> $z_{(1+\gamma)/2}$ in R_{11}
3. Press $\boxed{\text{B}}$ l is displayed, then

   press $\boxed{x \gtrless t}$ u is displayed

* Large here means np_X, mp_Y, $n(1-p_X)$, $m(1-p_Y)$ all greater than five.

C.I. For NORMAL $\mu_X - \mu_Y$ for paired X and Y (n pairs)

1. Enter data using DEP Sequence, degrees of freedom, $v = n-1$, will be displayed. (Alternate entry: store $\bar{x}-\bar{y}$ in R_{10}, $s_d/\sqrt{n}$ in R_{12} and $n-1$ in R_{19})
2. Store either $(1+\gamma)/2$ in R_{09} OR $t_{(1+\gamma)/2}(n-1)$ in R_{11}
3. Press $\boxed{C}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed
4. When differences, $x_i - y_i$, are given use Program 1.

C.I. For NORMAL $\mu_X - \mu_Y$ with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$ unknown

1. Enter data using DEI Sequence, degrees of freedom, $v = n+m-2$ is displayed. (Alternate entry #1: Store n in R_{15}, m in R_{03}, $\bar{x}-\bar{y}$ in R_{10}, $\sum(x_i-\bar{x})^2$ in R_{16}, $\sum(y_i-\bar{y})^2$ in R_{26} and $(n+m-2)$ in R_{19}) (Alternate entry #2: Store n in R_{03}, $\sum x_i$ in R_{01}, $\sum x_i^2$ in R_{02}, then press $\boxed{D'}$, store m in R_{03}, $\sum y_i$ in R_{01} and $\sum y_i^2$ in R_{02}, then press $\boxed{SBR}$ $\boxed{GTO}$, v is displayed)
2. Store either $(1+\gamma)/2$ in R_{09} OR $t_{(1+\gamma)/2}(n+m-2)$ in R_{11}
3. Press $\boxed{C}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed

C.I. For NORMAL $\mu_X - \mu_Y$ with σ_X^2 and σ_Y^2 known

1. Enter data using DEI Sequence, then store σ_X^2/n in R_{17} and σ_Y^2/m in R_{07} (Alternate entry: store $\bar{x}-\bar{y}$ in R_{10} and $\sqrt{(\sigma_X^2/n) + (\sigma_Y^2/m)}$ in R_{12})
2. Store either $(1+\gamma)/2$ in R_{09} OR $z_{(1+\gamma)/2}$ in R_{11}
3. Press $\boxed{A}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed

C.I. For NORMAL σ_X^2/σ_Y^2

1. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, s_X^2 in R_{17}, m in R_{03} and s_Y^2 in R_{07})
2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}(n-1,m-1)$ in R_{11} AND $F_{(1+\gamma)/2}(m-1,n-1)$ in R_{13}
3. Press $\boxed{E}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed

C.I. For EXPONENTIAL $\lambda_X/\lambda_Y = \mu_Y/\mu_X$

1. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, $\bar{x}$ in R_{18}, m in R_{03} and $\bar{y}$ in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}(2m,2n)$ in R_{11} AND $F_{(1+\gamma)/2}(2n,2m)$ in R_{13}
3. Press $\boxed{E'}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed

PROGRAM 2 ADDITIONAL CAPABILITIES:

Inverse Normal CDF Approximation

1. Store p in R_{09} ($p > .5$)
2. Press $\boxed{B'}$ to display z_p

Inverse Student's t CDF Approximation

1. Store p in R_{09} ($p > .5$) and v in R_{19} ($v \neq 1$)
2. Press $\boxed{SBR}$ $\boxed{RCL}$ to display $t_p(v)$

Inverse F CDF Approximation

1. Store p in R_{09} ($p > .5$), v_1 in R_{20} and v_2 in R_{21} ($v_1 \neq 1, v_2 \neq 1$)
2. Press $\boxed{SBR}$ $\boxed{STO}$ to display $F_p(v_1,v_2)$

PROGRAM 2 LABELS USED

A	A'	GTO	EE
B	B'	RST	
C	=	SBR	
D	D'	STO	
E	E'	RCL	

PROGRAM 2 STORAGE REGISTER CONTENTS:

00	clear	15	n
01	$n\bar{x}$ or $\sum y_i$	16	used
02	$m\bar{y}$ or $\sum y_i^2$	17	s_X^2 or σ_X^2/n
03	n or m	18	$\bar{x}$
04	m or $\sum x_i$	19	v or (n-1)
05	$\sum x_i^2$	20	v_1
06	$\sum x_i y_i$	21	v_2
07	s_Y^2 or σ_Y^2/m	22	clear
08	$\bar{y}$	23	used
09	p or $(1+\gamma)/2$	24	used
10	$\bar{x}-\bar{y}$	25	clear
11	CDF value	26	clear
12	$s_d/\sqrt{n}$	27	used
13	CDF value	28	used
14	used	29	used

PROGRAM 2 SAMPLE PROBLEMS:

1. In a survey of 400 people from one city 188 preferred Brand A soap to all others; and in a sample of 500 people from another city 210 preferred the same product. Find a 95% confidence interval for $p_X - p_Y$.

SOLUTION:

(1) Press $\boxed{D}$ then store $n\bar{x} = 188$ in R_{01}, $m\bar{y} = 210$ in R_{02}, $n = 400$ in R_{03} and $m = 500$ in R_{04}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $z_{.975} = 1.960$ in R_{11}

(3) Press $\boxed{B}$ then $\boxed{x \gtrless t}$ to display

l = -.0153123448	OR	l = -.0152991877
u = .1153123448		u = .1152991877

2. In a survey of dieting effects, ten women were selected, weighed and placed on a diet for two weeks. At the end of that time they were reweighed. The results are listed below. Find a 99% confidence interval for the difference in means. Also find a 95% upper confidence bound for the difference in means.

Before	119	122	136	130	129	136	134	133	119	115
After	114	119	134	126	119	137	124	127	119	107

SOLUTION Part a.

(1) Enter data using DEP Sequence, 9 is displayed

(2) Store $(1+\gamma)/2 = .995$ in R_{09} OR $t_{.995}(9) = 3.250$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

l = .7054594846	OR	l = .7328694249
u = 8.694540515		u = 8.667130575

SOLUTION Part b.

(1) Enter data using DEP Sequence, 9 is displayed

(2) Store $\gamma = .95$ in R_{09} OR $t_{.95}(9) = 1.833$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

ignore l	OR	ignore l
u = 6.929557002		u = 6.937461644

3. Suppose $\bar{x} = 10$, $\bar{y} = 5$, $n = 25$, and $s_d = 10$; find a 90% C.I. for $\mu_X - \mu_Y$.

SOLUTION:

(1) Press $\boxed{D}$ then s ore $\bar{x}-\bar{y} = 5$ in R_{10}, $s_d/\sqrt{n} = 2$ in R_{12} and $(n-1) = 24$ in R_{19}

(2) Store $(1+\gamma)/2$ in R_{09} OR $t_{.95}(24) = 1.711$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

l = 1.581803572	OR	l = 1.578
u = 8.418196428		u = 8.422

4. Two small classes used different, but equivalent methods on a common exam. Their scores are listed below. Find a 90% confidence interval and a 90% lower bound for the difference in means.

X: 82 87 91 54 97 76 64 98 92 57 80 53 64

Y: 91 62 94 92 87 79 86 75 90 73 83 93 65 89 68 52

SOLUTION: Part a.

(1) Enter data using DEI Sequence, v = 27 is displayed

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $t_{.95}(27) = 1.703$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

l = -12.62699316	OR	l = -12.63357801
u = 5.828916241		u = 5.835501092

SOLUTION Part b.

(1) Enter data using DEI Sequence, v = 27 is displayed

(2) Store γ = .90 in R_{09} OR $t_{.90}(27) = 1.314$ in R_{11}

(3) Press $\boxed{C}$ to display

l = -10.49428744 OR l = -10.52422048

ignore u OR ignore u

5. Suppose n = 16, m = 15, $\bar{x} = 14.3$, $\bar{y} = 12.5$, $\sum(x_i-\bar{x})^2 = 67.2$ and $\sum(y_i-\bar{y})^2 = 103.7$. Find a 99% upper confidence bound for the difference in means.

SOLUTION:

(1) Press $\boxed{D}$ then store n = 16 in R_{15}, m = 15 in R_{03}, $\bar{x}-\bar{y} = 1.8$ in R_{10}, $\sum(x_i-\bar{x})^2 = 67.2$ in R_{16}, $\sum(y_i-\bar{y})^2 = 103.7$ in R_{26} and (n+m-2) = 29 in R_{19}

(2) Store γ = .99 in R_{09} OR $t_{.99}(29) = 2.462$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

ignore l OR ignore l

u = 3.9597647 42 OR u = 3.948005095

6. Suppose n = 32, m = 10, $\bar{x} = 13$, $\bar{y} = 15$, $\sigma_X^2 = 16$ and $\sigma_Y^2 = 25$; find a 95% confidence interval for $\mu_X-\mu_Y$.

SOLUTION:

(1) Press $\boxed{D}$ then store $\bar{x}-\bar{y} = 2$ in R_{10} and $\sqrt{(\sigma_X^2/n) + (\sigma_Y^2/m)} = \sqrt{3}$ in R_{12}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $z_{.975} = 1.960$ in R_{11}

(3) Press $\boxed{A}$ then $\boxed{x \gtrless t}$ to display

l = -1.395503599 OR l = -1.394819583

u = 5.395503599 OR u = 5.394819583

7. Given the following sets of data with known variance, estimate the difference in means with a 90% confidence interval.

$\sigma_X^2 = 3.7$ and $\sigma_Y^2 = 2.5$

X: 3.6 4.7 2.4 1.7 6.2 7.2 3.6

Y: 5.4 7.6 4.3 6.5 8.7 4.5 6.1 8.6

SOLUTION:

(1) Enter data using DEI Sequence and store $\sigma_X^2/n = 3.7/7$ in R_{17} and $\sigma_Y^2/m = 2.5/8$ in R_{07}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $z_{.95} = 1.645$ in R_{11}

(3) Press $\boxed{A}$ then $\boxed{x\gtrless t}$ to display

l = -3.771322531	OR	l = -3.77112862
u = -.7536774686		u = -.7538713802

8. Find a 99% confidence interval for σ_X^2/σ_Y^2 using the following data.

X: 82 87 91 54 97 76 64 98 92 57 80 53 64

Y: 91 62 94 92 87 79 86 75 90 73 83 93 65 89 68 52

SOLUTION:

(1) Enter data using DEI Sequence

(2) Store $(1+\gamma)/2 = .995$ in R_{09} OR $F_{.995}(12,15)=4.25$ in R_{11}

AND

$F_{.995}(15,12) = 4.72$ in R_{13}

(3) Press $\boxed{E}$ then $\boxed{x\gtrless t}$ to display

l = .3864689829	OR	l = .3875258108
u = 7.818933411		u = 7.773767765

9. Find a 95% confidence interval for σ_X^2/σ_Y^2 given n = 8, m = 11, $s_X^2 = 4$ and $s_Y^2 = 3.6$.

SOLUTION:

(1) Press $\boxed{D}$ then store n = 8 in R_{15}, m = 11 in R_{03}, $s_X^2 = 4$ in R_{17} and $s_Y^2 = 3.6$ in R_{07}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $F_{.975}(7,10) = 3.95$ in R_{11}

AND

$F_{.975}(10,7) = 4.76$ in R_{13}

(3) Press $\boxed{E}$ then $\boxed{x \gtrless t}$ to display

l = .280241493 OR l = .2812939522

u = 5.35837828   u = 5.288888889

10. Find a 90% confidence interval for μ_Y/μ_X given the following data:

X:	17	6	12	14	3	12	15
Y:	7	15	4	6	21	13	

SOLUTION:

(1) Enter data using DEI Sequence

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(12,14) = 2.55$ in R_{11}

AND

$F_{.95}(14,12) = 2.64$ in R_{13}

(3) Press $\boxed{E'}$ then $\boxed{x \gtrless t}$ to display

l = .3688954123 OR l = .3822288409

u = 2.472430016   u = 2.573164557

11. Two types of electric bulbs are observed as to length of life, yeilding the following results. Are the means significantly different? (α = .1)

Type 1 $n = 46$ $\bar{x} = 1070$

Type 2 $m = 64$ $\bar{y} = 1041$

SOLUTION:

(1) Press $\boxed{D}$ then store $n = 46$ in R_{15}, $m = 64$ in R_{03}, $\bar{x} = 1070$ in R_{18} and $\bar{y} = 1041$ in R_{08}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(98,128) = 1.33$ in R_{11}

AND

$F_{.95}(128,98) = 1.40$ in R_{13}

(3) Press $\boxed{E'}$ then $\boxed{x \gtrless t}$ to display

$l = .7102715868$ OR $l = .7315016513$

$u = 1.345613548$ $u = 1.362056075$

Thus with 90% confidence the means are not different.

PROGRAM 3 USER GUIDE - One-Population Hypothesis Tests

INTRODUCTION: The purpose of this program is to perform one-tailed or two-tailed hypothesis tests for the following one-population situations:

NORMAL	μ_o	with σ^2 known
NORMAL	μ_o	with σ^2 unknown
BERNOULLI	p_o	
NORMAL	σ_o^2	with μ known
NORMAL	σ_o^2	with μ unknown
EXPONENTIAL	$\mu_o = 1/\lambda_o$	
POISSON	λ_o	

GENERAL PROCEDURES:

1. This program requires the Applied Statistics Module. After reading all three card edges, press $\boxed{E'}$ to repartition (719.29).

2. For each new problem press $\boxed{E'}$ to clear all registers and to prepare for the following parameter entries. Enter θ_o and press $\boxed{R/S}$, enter α and press $\boxed{R/S}$, then enter either 0, -1 or +1 for the desired alternate hypothesis, as in the table below, and press $\boxed{R/S}$.

0 for $H_1: \theta \neq \theta_o$, Two-tailed test

-1 for $H_1: \theta < \theta_o$, Lower-tailed test

+1 for $H_1: \theta > \theta_o$, Upper-tailed test

3. For data entry press $\boxed{D}$ followed by data point x_i, $\boxed{R/S}$, x_{i+1}, $\boxed{R/S}$, etc. for each x_i $(i=1,2,\ldots,n)$ until all data points have been entered. Mistakes in data entry should be corrected immediately by reentering the unwanted data point and pressing $\boxed{INV}$ $\boxed{2nd}$ $\boxed{\Sigma +}$, then enter the correct data point and press $\boxed{R/S}$ $\boxed{R/S}$. Alternate data entry using summary statistics is detailed in each subroutine.

4. At the conclusion of each test a 1 for Reject or a 0 for Accept is displayed. The significance level for each test is usually in the T-register (R_T); however, for two-tailed unsymmetric tests the test statistic stored in R_{12} is used as follows: if a 0 is displayed then the test must have failed to reject in both tails. If a 1 is displayed then the test was upper-tailed if R_{12} is greater than the median and lower-tailed if R_{12} is less than the median.

PROGRAM 3 SPECIFIC PROCEDURES:

Tests for NORMAL μ_o with σ^2 known

1. Press [E'], enter μ_o, press [R/S], enter α, press [R/S], enter 0, -1 or +1 and press [R/S].
2. Enter data using [D] and store σ in R_{07} (Alternate entry: store n in R_{03}, $\bar{x}$ in R_{10} and σ in R_{07}).
3. Press [A] either 1 (reject) or 0 (accept) is displayed, press [x≷t] to display significance level.

Tests for NORMAL μ_o with σ^2 unknown

1. Press [E'], enter μ_o, press [R/S], enter α, press [R/S], enter 0, -1 or +1 and press [R/S].
2. Enter data using [D] (Alternate entry: store n in R_{03}, $\bar{x}$ in R_{10} and s_X in R_{14}).
3. [C] either 1 (reject) or 0 (accept) is displayed, then press [x≷t] to display significance level.

Tests For Bernoulli p_o

1. Press $\boxed{E'}$, enter p_o, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Store $n\bar{x}$ in R_{01} and n in R_{03}.
3. Press $\boxed{B}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For NORMAL σ_o^2 with μ known

1. Press $\boxed{E'}$, enter σ_o^2, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ and store μ in R_{10} (Alternate entry: store n in R_{03}, $\sum x_i$ in R_{01}, $\sum x_i^2$ in R_{02} and μ in R_{10}).
3. Press $\boxed{D'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For NORMAL σ_o^2 with μ unknown

1. Press $\boxed{E'}$, enter σ_o^2, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03} and $(n-1)s_X^2$ in R_{10}).
3. Press $\boxed{A'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For EXPONENTIAL $\mu_o = 1/\lambda_o$

1. Press $\boxed{E'}$, enter μ_o, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ (Alternate: store n in R_{03} and $\bar{x}$ in R_{10}).
3. Press $\boxed{E}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For POISSON λ_o

1. Press $\boxed{E'}$, enter λ_o, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03} and $n\bar{x}$ in R_{01}).
3. Press $\boxed{B'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

PROGRAM 3 LABELS USED

A	A'	TAN	LNX
B	B'	SIN	LOG
C	C'	COS	INV
D	D'	CLR	FIX
E	E'	GRD	INT
×	+	SUM	ENG
÷	-	CE	

PROGRAM 3 STORAGE REGISTER CONTENTS

00	0, -1 or +1	10	$\bar{x}$ or μ or $(n-1)s_X^2$
01	$n\bar{x}$ or $\sum x_i$	11	α
02	$\sum x_i^2$	12	test statistic
03	n	13	clear
04	clear	14	s_X
05	clear	15-29	used
06	degrees of freedom		
07	σ		
08	μ_o or σ_o^2 or p_o or λ_o		
09	clear		

PROGRAM 3 SAMPLE PROBLEMS:

1. According to an early encyclopedia the average rainfall in a city is 30.1 inches. Rainfall during the past five years has been:

   30.5   27.4   35.1   32.6   25.9

   Assuming a standard deviation of .2 inches, has the average changed?

   SOLUTION: H_0: $\mu = 30.1$, H_1: $\mu \neq 30.1$, $\alpha = .05$

   (1) Press $\boxed{E'}$, 30.1, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

   (2) Enter data using $\boxed{D}$, store $\sigma = .2$ in R_{07}

   (3) Press $\boxed{A}$ 1 is displayed (reject H_0),

   $\boxed{x \gtrless t}$ sl = .0253472347 .

2. A new fad diet was tried out on 15 subjects and the weight losses after one week were:

   2.07 2.34 1.97 1.85 1.84 2.23 2.15 1.89

   1.93 1.99 1.86 1.90 2.09 2.16 2.04

   An advertisement claims that the weight loss after one week on the diet is at least two pounds. Do the data support the claim?($\alpha = .05$)

   SOLUTION: H_0: $\mu \geq 2$, H_1: $\mu < 2$

   (1) Press $\boxed{E'}$, 2, $\boxed{R/S}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

   (2) Enter data using $\boxed{D}$.

   (3) Press $\boxed{C}$ 0 is displayed (accept H_0),

   $\boxed{x \gtrless t}$ sl = .302539836 .

3. It is claimed that a certain drug will lower temperature within ten minutes. Five subjects having normal temperatures of 98.6 were given the drug and ten minutes later their temperatures were recorded in summary form as follows: $\sum x = 491$, $\sum x^2 = 48219$. Test the claim at the $\alpha = .05$ level.

SOLUTION: $H_o: \mu \leq 98.6$, $H_1: \mu > 98.6$

(1) Press $\boxed{E'}$, 98.6, $\boxed{R/S}$, .05, $\boxed{R/S}$, -1, $\boxed{R/S}$.

(2) Store n = 5 in R_{03}, $\bar{x} = 491/5$ in R_{10} and $s_X = \frac{48219-5\bar{x}^2}{4}$ in R_{14}

(3) Press $\boxed{C}$ 0 is displayed (accept H_o),

$\boxed{x \gtrless t}$ sl = .1352267548 .

4. A student claims he can always answer more than half of the items on a true-false exam correctly, regardless of the topic. You devise a 20 question exam on a subject of which he knows nothing and he answers 12 of the test items correctly. Would you conclude he has extraordinary powers? (α = .05)

SOLUTION: $H_o: \mu = .5$, $H_1: \mu > .5$

(1) Press $\boxed{E'}$, .5, $\boxed{R/S}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Store $n\bar{x}$ = 12 in R_{01} and n = 20 in R_{03}.

(3) Press $\boxed{B}$ 0 is displayed (accept H_o),

$\boxed{x \gtrless t}$ sl = .2517223358 .

5. Of 694 respondents, 369 were in favor of more dissemination of birth control information. Is it safe to conclude that more than half of the population agrees with this position? (α = .05)

SOLUTION: $H_o: \mu \leq .5$, $H_1: \mu > .5$

(1) Press $\boxed{E'}$, .5, $\boxed{R/S}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Store $n\bar{x}$ = 369 in R_{01} and n = 694 in R_{03}

(3) Press $\boxed{B}$ 1 is displayed (reject H_o),

$\boxed{x \gtrless t}$ sl = .0474381802 .

6. A soup can filling machine is supposed to fill each can with ten ounces of clear broth, with a variance of .01. A change in variability in either direction is undesirable. A random sample of 20 cans yeilded $\sum x^2 = 2107.7$ and $\sum x = 205.3$. Is the machine working within limits? ($\alpha = .05$)

<u>SOLUTION:</u> $H_o: \sigma^2 = .01$, $H_1: \sigma^2 \neq .01$

(1) Press $\boxed{E'}$, .01, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Store n = 20 in R_{03}, $\sum x = 205.3$ in R_{01}, $\sum x^2 = 2107.7$ in R_{02} and $\mu = 10$ in R_{10}

(3) Press $\boxed{D'}$ 1 is displayed (reject H_o).

7. A nail machine is supposed to manfacture 1-inch nails with a standard deviation of .025 inches. A random sample of 30 nails yeilded a sample value for s_X of .03 inches. Does this apparent increase warrant shutting the machine down? ($\alpha = .05$)

<u>SOLUTION:</u> $H_o: \sigma^2 \leq (.025)^2$, $H_1: \sigma^2 > (.025)^2$

(1) Press $\boxed{E'}$, .000625, $\boxed{R/S}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Store n = 30 in R_{03} and $(n-1)s^2 = 29(.03)^2$ in R_{10}

(3) Press $\boxed{A'}$ 0 is displayed (accept H_o)

$\boxed{x \gtrless t}$ sl = .059

8. A certain type of expensive electrical gear is supposed to have a mean life of 1000 hours. The manfacturer is concerned if the mean departs in either direction from 1000. Five components were tested and they had the following burnout times:

1075 1085 1060 998 995

Is the mean still 1000? ($\alpha = .05$)

SOLUTION: $H_o: \mu = 1000$, $H_1: \mu \neq 1000$

(1) Press $\boxed{E'}$, 1000, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using $\boxed{D}$

(3) Press $\boxed{E}$ 0 is displayed (accept H_o)

9. Over a period of years there had been an average of 14 accidents per year in a certain city. This year the monthly totals were as follows: 1 0 2 2 1 1 3 0 1 0 1 2. Does this data agree with the theory that the number of accidents per month follows a poisson distribution with $\lambda = 1.1667$? ($\alpha = .05$)

SOLUTION: $H_o: \lambda = 1.1667$, $H_1: \lambda \neq 1.1667$

(1) Press $\boxed{E'}$, 1.1667, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using $\boxed{D}$

(3) Press $\boxed{B'}$ 0 is displayed (accept H_o)

$\boxed{x \gtrless t}$ sl = .5703943172

PROGRAM 4 USER GUIDE - Two-Population Hypothesis Tests

INTRODUCTION: The purpose of this program is to perform one-tailed and two-tailed hypothesis tests for the following two-population situations.

BERNOULLI	$p_X = p_Y$	for large sample sizes
NORMAL	$\mu_X = \mu_Y$	for X and Y paired
NORMAL	$\mu_X = \mu_Y$	for X and Y independent with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$
NORMAL	$\mu_X = \mu_Y$	for X and Y independent with σ_X^2, σ_Y^2 known
NORMAL	$\mu_X = \mu_Y$	for X and Y independent with $\sigma_X^2 \neq \sigma_Y^2$
NORMAL	$\sigma_X^2 = \sigma_Y^2$	for X and Y independent
NORMAL	$\rho = 0$	for X and Y paired
EXPONENTIAL	$\lambda_X = \lambda_Y$	for X and Y independent

GENERAL PROCEDURES:

1. This program requires the Applied Statistics Module. After reading all three card edges, press $\boxed{E'}$ to repartition (719.29).

2. For each new problem press $\boxed{E'}$ to clear all registers and to prepare for the following parameter entries. Enter α and press $\boxed{R/S}$ then enter either 0, -1 or +1 for the desired alternate hypothesis, as in the table below, and press $\boxed{R/S}$.

   0 for H_1: $\theta_X \neq \theta_Y$, Two-tailed test

   -1 for H_1: $\theta_X < \theta_Y$, Lower-tailed test

   +1 for H_1: $\theta_X > \theta_Y$, Upper-tailed test

3. For independent data entry (DEI Sequence) press $\boxed{D}$ followed by data point x_i, $\boxed{R/S}$, x_{i+1}, $\boxed{R/S}$, etc. for each x_i $(i=1,2,\ldots,n)$. When all x_i's have been entered press $\boxed{D}$ again, followed by data point y_i, $\boxed{R/S}$, y_{i+1}, $\boxed{R/S}$, etc. for each y_i $(i=1,2,\ldots,m)$. When all of the y_i's have been entered press $\boxed{D}$. Mistakes in data entry should be

corrected immediately by reentering the unwanted data point and pressing INV 2nd Σ+ , then enter the correct data point and press R/S R/S. Alternate data entry is detailed in each subroutine.

4. For paired data entry (DEP Sequence) press D followed by x_i, x⇄t , y_i R/S , x_{i+1}, x⇄t , y_{i+1}, R/S , etc. when all of the paired data points have been entered press SBR RST . Mistakes and alternate entry are as above.

5. Each routine displays either a 1 for Reject or a 0 for Accept. The significance level is always in the T-register (R_T).

PROGRAM 4 SPECIFIC PROCEDURES:

Tests for BERNOULLI $p_X=p_Y$ for large sample sizes

1. Press E' , enter α, press R/S , enter 0, -1 or +1 , and press R/S .
2. Store n in R_{15}, $n\bar{x}$ in R_{04}, m in R_{03} and $m\bar{y}$ in R_{01} .
3. Press B either 1 (reject) or 0 (accept) is displayed, then press x⇄t to display significance level.

Tests for NORMAL $\mu_X= \mu_Y$ for X and Y paired

1. Press E' , enter α, press R/S , enter 0, -1 or +1 and then press R/S .
2. Enter data using DEP Sequence (Alternate entry: store (n-1) in R_{25} and $\bar{d}(\sqrt{n}/s_d)$ in R_{10})
3. Press B' either 1 (reject) or 0 (accept) is displayed, then press x⇄t to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0 , -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, m in R_{03}, $\bar{x}$ in R_{14}, $\bar{y}$ in R_{08}, s_X^2 in R_{09} and s_Y^2 in R_{07})
3. Press $\boxed{C}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ for σ_X^2 and σ_Y^2 known

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence and store σ_X^2 in R_{09} and σ_Y^2 in R_{07} (Alternate entry: store n in R_{15}, m in R_{03}, $\bar{x}$ in R_{14}, $\bar{y}$ in R_{08}, σ_X^2 in R_{09} and σ_Y^2 in R_{07})
3. Press $\boxed{A}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ for $\sigma_X^2 \neq \sigma_Y^2$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, m in R_{03}, $\bar{x}$ in R_{14}, $\bar{y}$ in R_{08}, s_X^2 in R_{09} and s_Y^2 in R_{07}).
3. Press $\boxed{C'}$, 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL $\sigma_X^2 = \sigma_Y^2$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.

2. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, m in R_{03}, s_X^2 in R_{09} and s_Y^2 in R_{07}).

3. Press $\boxed{D'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\gtrless t}$ to display significance level.

Tests for NORMAL $\rho = 0$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.

2. Enter data using DEP Sequence (no alternate entry).

3. Press $\boxed{A'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\gtrless t}$ to display significance level.

Tests for EXPONENTIAL $\lambda_X = \lambda_Y$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.

2. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, m in R_{03}, $\bar{x}$ in R_{14} and $\bar{y}$ in R_{08}).

3. Press $\boxed{E}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\gtrless t}$ to display significance level.

PROGRAM 4 LABELS USED

A	A'	SIN	RST	GTO
B	B'	COS	CLR	x^2
C	C'	DEG	RCL	+
D	D'	INV	STO	-
E	E'	GRD	EXC	

PROGRAM 4 STORAGE REGISTER CONTENTS:

00	0, -1 or +1	07	s_Y^2 or σ_Y^2	14	$\bar{x}$
01	$m\bar{y}$ or $\sum y$	08	$\bar{y}$	15	n
02	$\sum y^2$	09	s_X^2 or σ_X^2	16 - 24	used
03	m or n	10	$\bar{d}(\sqrt{n}/s_d)$	25	(n-1)
04	$n\bar{x}$ or $\sum x$	11	α	26 - 29	used
05	$\sum x^2$	12	used		
06	$\sum xy$	13	used		

PROGRAM 4 SAMPLE PROBLEMS:

1. According to last year,s statistics, 70% of the population were in favor of stricter smog control laws. This year only 65% of 1000 respondents favored stricter laws. Does this represent a significant decrease? (α = .01)

   SOLUTION: H_o: $p_X = p_Y$, H_1: $p_X > p_Y$

   (1) Press $\boxed{E'}$, .01, $\boxed{R/S}$, +1, $\boxed{R/S}$.

   (2) Store n = 1000 in R_{15}, $n\bar{x}$ = 700 in R_{04}, m = 1000 in R_{03} and $m\bar{y}$ = 650 in R_{01}.

   (3) Press $\boxed{B}$ 1 is displayed (reject H_o)

   $\boxed{x \rightleftarrows t}$ sl = .0084920904

2. Ten plots are split and half planted with variety A and half with variety B. The yields are shown below. Is there a difference in mean yield between the two varieties? (α = .10)

A:	49	58	53	60	45	49	66	55	44	52
B:	47	57	49	57	44	44	67	52	42	53

   SOLUTION: H_o: $\mu_A = \mu_B$, H_1 $\mu_A \neq \mu_B$

   (1) Press $\boxed{E'}$, .10, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using DEP Sequence.

(3) Press $\boxed{B'}$ 1 is displayed (reject H_o)

$\boxed{x \gtrless t}$ sl = .0137674905

3. A cigarette manufacturer tests tobacco from two different brands for nicotine content and obtains the following (in milligrams).

A:	24	26	25	22	23
B:	27	28	25	29	26

Do these results indicate there is a difference in mean nicotine content for the two brands? (α = .05)

<u>SOLUTION:</u> $H_o: \mu_A = \mu_B$, $H_1: \mu_A \neq \mu_B$

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using DEI Sequence.

(3) Press $\boxed{C}$ 1 is displayed (reject H_o)

$\boxed{x \gtrless t}$ sl = .0170716812

4. Two analysts make fifty independent determinations of the melting point of a certain chemical. The sample mean and variance of the data found by analyst I are respectively, 73.6 and 10 while the sample mean and variance found by analyst II are, respectively, 72.4 and 8 . It is argued that there is a tendency for analyst I to get higher results. What is your conclusion? (α = .05)

<u>SOLUTION:</u> $H_o: \mu_X = \mu_Y$, $H_1: \mu_X > \mu_Y$

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Store n = 50 in R_{15}, m = 50 in R_{03}, $\bar{x}$ = 73.6 in R_{14}, $\bar{y}$ = 72.4 in R_{08}, s_X^2 = 10 in R_{09} and s_Y^2 = 8 in R_{07}.

(3) Press $\boxed{C}$ 1 is displayed (reject H_o)

$\boxed{x \gtrless t}$ sl = .022750062

5. We are interested in replacing wire B with wire A if the resistance per unit length is not significantly decreased. The results of twenty tests on each wire are presented below. If we know that the standard deviation of the two testing procedures are both .0017 ohms. What is your recommendation? ($\alpha = .01$)

A	.051	.051	.049	.048	.049	.049	.049	.053	.053	.049
	.049	.047	.048	.049	.049	.051	.051	.050	.047	.050
B	.054	.052	.051	.049	.051	.057	.054	.052	.050	.052
	.051	.051	.055	.049	.052	.051	.051	.052	.052	.048

<u>SOLUTION</u>: H_o: $\mu_A \leq \mu_B$, H_1: $\mu_A > \mu_B$.

(1) Press $\boxed{E'}$, .01, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Enter data using DEI Sequence and store $\sigma_X^2 = (.0017)^2$ in R_{09} and $\sigma_Y^2 = (.0017)^2$ in R_{07}

(3) Press $\boxed{A}$ 0 is displayed (accept H_o)

$\boxed{x \rightleftarrows t}$ sl = .500837784

6. Twenty plots of ground were planted with corn. Ten plots (Y) contained a special treatment. The variances were tested and found to be unequal. Is there a significant difference between the yields at the 5% level?

$\bar{x} = 6.1$ $\bar{y} = 5.78$

$s_X^2 = .13556$ $s_Y^2 = .02844$

<u>SOLUTION</u>: H_o: $\mu_X = \mu_Y$, H_1: $\mu_X \neq \mu_Y$.

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$

(2) Store n = 10 in R_{15}, m = 10 in R_{03}, $\bar{x} = 6.1$ in R_{14}, $\bar{y} = 5.78$ in R_{08}, $s_X^2 = .13556$ in R_{09} and $s_Y^2 = .02844$ in R_{07}.

(3) Press $\boxed{C'}$ 1 is displayed (reject H_o)

$\boxed{x \rightleftarrows t}$ sl = .026650012

7. Suppose that two samples of ten and sixteen observations have, respectively, variances of .3888 and 2.25 . At the 5% significance level would you accept the hypothesis that $\sigma_1^2 \leq \sigma_2^2$?

<u>SOLUTION</u>: H_o: $\sigma_X^2 \leq \sigma_Y^2$, H_1: $\sigma_X^2 > \sigma_Y^2$.

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, -1, $\boxed{R/S}$.

(2) Store n = 10 in R_{15}, m = 16 in R_{03}, s_X^2 = .3888 in R_{09} and s_Y^2 = 2.25 in R_{07}.

(3) $\boxed{D'}$ 0 is displayed (accept H_o)

$\boxed{x \gtrless t}$ sl = .994190704 .

8. The following data measurements of students' ability in an IQ test are paired with scores in an acheivement test. Test for $\rho = 0$.

X:	105	95	125	92	120	107	121	90	132	116
Y:	47	46	53	31	64	43	75	40	80	55

<u>SOLUTION</u>: H_o: $\rho = 0$, H_1: $\rho \neq 0$

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using DEP Sequence

(3) Press $\boxed{A'}$ 1 is displayed (reject H_o)

$\boxed{x \gtrless t}$ sl = .0012735515

9. Two types of electric bulbs are observed as to length of life, with the following results: n = 46, m = 64, $\bar{x}$ = 1070 and $\bar{y}$ = 1041. Are the mean lives significantly different? (α = .10)

<u>SOLUTION</u>: H_o: $\lambda_X = \lambda_Y$, H_1: $\lambda_X \neq \lambda_Y$

(1) Press $\boxed{E'}$, .1, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Store n = 46 in R_{15}, m = 64 in R_{03}, $\bar{x}$ = 1070 in R_{14} and $\bar{y}$ = 1041 in R_{08} .

(3) $\boxed{E}$ 0 is displayed (accept H_o)

$\boxed{x \gtrless t}$ sl = .5605970415

USER GUIDE FOR FIVE DISTRIBUTION PROGRAMS

INTRODUCTION: The purpose of these five programs is to provide accurate approximate values for the following distributions: Normal, Binomial/ Multinomial, Chi-square, Student's t, and F.

GENERAL PROCEDURES: Read in the appropriate program and proceed as below.

NORMAL Distribution - Program 5

Proceed with the following steps in any order.

	Enter	Press	Display
1.	z	A	$\phi(z)$ = normal density at z
2.	z	B	$P(z) = P(Z \leq z)$
3.	P(z)	C	z_p = normal p^{th} percentile
4.	z	D	$Q(z) = P(Z > z)$
5.	z	E	$A(z) = P(Z \leq \lvert z \rvert)$

BINOMIAL Distribution - Program 6

Perform the first two steps and then do the remaining steps in any order.

	Enter	Press	Display
1.	n	A	n
2.	p	B	p
3.	k	C	$f(k;n,p)$ = binomial density at k
4.	k	D	$F(k;n,p) = P(Z \leq k)$
5.	k	E	$Q(k) = P(Z > k)$
6.	-	A'	μ
7.	-	B'	σ

MULTINOMIAL Density - Program 6

Perform the following steps in order. Step 2 must be completed for each set (n_i, p_i) for $i=1,2,\ldots,k$. $(k \leq 35)$

	Enter	Press	Display
1.	N	C'	-
2.	n_i	$x \gtrless t$	$\sum n_i$ (can be used to check $\sum n_i = N$)
	p_i	R/S	$\sum p_i$ (can be used to check $\sum p_i = 1$)
3.	-	D'	$f(n_1, n_2, \ldots, n_k)$

* As an added feature the following capability exists in Program 6.

4. Store N in R_{07} and press E' to display $N!$ $(N \leq 69)$.

CHI-SQUARE Distribution - Program 7

Store v in R_{15} and then the following steps in any order.

	Enter	Press	Display
1.	χ^2	A	$f(\chi^2)$ = density at χ^2
2.	χ^2	B	$P(\chi^2) = P(Z \geq \chi^2)$
3.	$P(\chi^2)$	C	$\chi^2_p(v) = p^{th}$ percentile

* As an added feature the Gamma function can be evaluated as below.

4.	v	D	$\Gamma(v/2)$

STUDENT'S t Distribution - Program 8

Store v in R_{15} and then the following steps in any order.

	Enter	Press	Display
1.	t	A	$f(t)$ = density at t
2.	t	B	$P(t) = P(Z \geq t)$
3.	$P(t)$	C	$t_p(v) = p^{th}$ percentile

* As an added feature the Gamma function can be evaluated as below.

5. Store v in R_{15} and press D to display $\Gamma(v/2)$.

F Distribution - Program 9

Complete Steps 1 and 2 prior to Steps 3 or 4 below.

	Enter	Press	Display
1.	v_1	$\boxed{x \gtrless t}$	-
2.	v_2	$\boxed{A}$	-
3.	$F(v_1, v_2)$	$\boxed{B}$	$P(F) = P(Z \geq F)$
4.	$P(F)$	$\boxed{C}$	$F_p(v_1, v_2) = p^{th}$ percentile

PROGRAM 5 LABELS USED

A B C D E D' E'

PROGRAM 6 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 7 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 8 LABELS USED

A B C D E B' C' E'

PROGRAM 9 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 5 REGISTERS USED

9 11 25 26 29

PROGRAM 6 REGISTERS USED - ALL

PROGRAM 7 REGISTERS USED

01 09 10 11 13 14 15 17 thru 23

PROGRAM 8 REGISTERS USED

00 02 09 10 15 thru 24

PROGRAM 9 REGISTERS USED

00 02 08 09 11 15 thru 29

PROGRAM 5 - Sample Problems

1. Find $\phi(1.960)$.

SOLUTION:

Enter 1.960 and press $\boxed{A}$, .0584409443 is displayed

2. Find $P(1.960) = P(Z \leq 1.960)$

SOLUTION:

Enter 1.960 and press $\boxed{B}$, .9750021748 is displayed

3. Find $P(-1.960)$.

SOLUTION:

Enter -1.960 and press $\boxed{B}$, .0249978252 is displayed.

4. Find $z_{.05}$

SOLUTION:

Enter .05 and press $\boxed{C}$, -1.64521144 is displayed.

5. Find $z_{.95}$

SOLUTION:

Enter .95 and press $\boxed{C}$, 1.64521144 is displayed.

6. Find $Q(1.282) = P(Z > 1.282)$

SOLUTION:

Enter 1.282 and press $\boxed{D}$, .0999213886 is displayed.

7. Find $A(1.282) = P(Z \leq |z|)$

SOLUTION:

Enter 1.282 and Press $\boxed{E}$, .8001572228 is displayed.

PROGRAM 6 SAMPLE PORBLEMS

1. Find f(k;n,p) given k = 6, n = 10 and p = .4 .

SOLUTION:

Enter 10 press $\boxed{A}$ then enter .4 press $\boxed{B}$ then

enter 6 press $\boxed{C}$, .111476736 is displayed.

2. Find P(8) when n = 10 and p = .75 .

SOLUTION:

Enter 10 press $\boxed{A}$ then enter .75 press $\boxed{B}$ then

enter 8 press $\boxed{D}$, .7559747696 is displayed.

3. Find Q(2) when n = 10 and p = .25 .

SOLUTION:

Enter 10 press $\boxed{A}$ then enter .25 press $\boxed{B}$ then

enter 2 press $\boxed{E}$, .474407196 is displayed.

4. Find μ and σ for a Binomial distribution with n = 20 and p = .5 .

SOLUTION:

Enter 20 press $\boxed{A}$ then enter .5 press $\boxed{B}$ then

press $\boxed{A'}$ μ = 10 is displayed, then

press $\boxed{B'}$ σ^2 = 2.236067977 is displayed.

5. Find $f(n_i)$ for the following Multinomial case.

n_i	1	2	3	4
p_i	.4	.3	.2	.1

SOLUTION:

Enter 10 press $\boxed{C'}$ then

enter n_i $\boxed{x\gtrless t}$ p_i $\boxed{R/S}$ etc. and

press $\boxed{D'}$, .00036288 is displayed.

PROGRAM 7 Sample Problems

1. Find f(25) where v = 15.

SOLUTION:

Store 15 in R_{15} , then enter 25 and press $\boxed{A}$

.0134298528 is displayed.

2. Find P(25) where v = 15.

SOLUTION:

Store 15 in R_{15} , then enter 25 and press $\boxed{B}$

.9500565664 is displayed.

3. Find $\chi^2_{.99}(16)$.

SOLUTION:

Store 16 in R_{15} , then enter .99 and press $\boxed{C}$

31.99987803 is displayed.

4. Find $\Gamma(8)$.

SOLUTION:

Enter 16 press $\boxed{D}$, 5040 is displayed.

PROGRAM 8 Sample Problems

1. Find f(2) where v = 20.

SOLUTION:

Store 20 in R_{15} , then enter 2 and press $\boxed{A}$

.0580872152 is displayed.

2. Find P(-.860) where v = 20.

SOLUTION:

Store 20 in R_{15} , then enter -.860 and press $\boxed{B}$

.199990431 is displayed.

3. Find $t_{.90}(14)$.

SOLUTION:

Store 14 in R_{15}, then enter .90 and press $\boxed{C}$

1.345266653 is displayed.

4. Find $\Gamma(4.5)$.

SOLUTION:

Store 9 in R_{15}, then press $\boxed{D}$

11.6317284 is displayed.

PROGRAM 9 - Sample Problems

1. Find P(2.52) where $v_1 = 5$ and $v_2 = 10$.

SOLUTION:

Enter 5 and press $\boxed{x \gtrless t}$, then enter 10 and press $\boxed{A}$

enter 2.52 and press $\boxed{B}$, .8998498088 is displayed.

2. Find P(.397) where $v_1 = 10$ and $v_2 = 5$.

SOLUTION:

Enter 10 and press $\boxed{x \gtrless t}$, then enter 5 and press $\boxed{A}$

enter .397 and press $\boxed{B}$, .1002517964 is displayed.

3. Find $F_{.975}(10,30)$.

SOLUTION:

Enter 10 and press $\boxed{x \gtrless t}$, then enter 30 and press $\boxed{A}$

enter .975 and press $\boxed{C}$, 2.511201637 is displayed.

APPENDIX B

SELECTED CHI-SQUARE INVERSE CDF APP?OXIMATIONS

	DEGREES OF FREEDOM	TABLED VALUE*	TYPE I APPROXIMATE PERCENTILE	TYPE I ACTUAL PROBABILITY	TYPE II APPROXIMATE PERCENTILE	TYPE II ACTUAL PROBABILITY
$\chi^2_{.05}$	1	.0039	.0000	.0001	.0039	.0499
	2	.1026	.0789	.0387	.1026	.0500
	3	.352	.3280	.0453	.3531	.0503
	4	.711	.6900	.0474	.7115	.0501
	5	1.15	1.1277	.0484	1.1460	.0500
	10	3.94	3.9307	.0496	3.9404	.0500
	15	7.26	7.2543	.0498	7.2610	.0500
	20	10.85	10.8455	.0499	10.8508	.0500
	30	18.49	18.4885	.0499	18.4927	.0500
	40	26.51	26.5056	.0499	same as TYPE I	
	60	43.19	43.1843	.0500	" " "	
	120	95.70	95.6999	.0500	" " "	
$\chi^2_{.90}$	1	2.71	2.6395	.8958	2.7067	.9001
	2	4.61	4.5596	.8977	4.6052	.9000
	3	6.25	6.2146	.8984	6.2517	.9000
	4	7.78	7.7480	.8987	7.7797	.9000
	5	9.24	9.2086	.8990	9.2366	.9000
	10	15.99	15.9688	.8995	15.9873	.9000
	15	22.31	22.2930	.8997	22.3072	.9000
	20	28.41	28.4003	.8997	28.4120	.9000
	30	40.26	40.2473	.8998	40.2560	.9000
	40	51.81	51.7981	.8999	same as TYPE I	
	60	74.40	74.3923	.8999	" " "	
	120	140.23	140.2309	.9000	" " "	
$\chi^2_{.995}$	1	7.88	7.9071	.9951	7.8815	.9950
	2	10.60	10.6753	.9952	10.5966	.9950
	3	12.84	12.9227	.9952	12.8377	.9950
	4	14.86	14.9437	.9952	14.8602	.9950
	5	16.75	16.8303	.9952	16.7497	.9950
	10	25.19	25.2557	.9951	25.1884	.9950
	15	32.80	32.8604	.9951	32.8015	.9950
	20	40.00	40.0502	.9951	39.9970	.9950
	30	53.67	53.7181	.9951	53.6721	.9950
	40	66.77	66.8076	.9950	same as TYPE I	
	60	91.95	91.9879	.9950	" " "	
	120	163.64	163.6777	.9950	" " "	

* [Ref. 2: p. 465]

SELECTED STUDENT'S t INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM		TABLED VALUE*	TYPE I APPROXIMATE PERCENTILE	TYPE I ACTUAL PROBABILITY	TYPE II APPROXIMATE PERCENTILE	TYPE II ACTUAL PROBABILITY
$t_{.60}$	1	.325	.2568	.5800	.3249	.6000
	2	.289	.2593	.5902	.2869	.5994
	3	.277	.2556	.5926	.2754	.5996
	4	.271	.2547	.5942	.2699	.5997
	5	.267	.2542	.5953	.2667	.5999
	10	.260	.2535	.5975	.2660	.5999
	15	.258	.2533	.5983	.2578	.6000
	20	.257	.2532	.5987	.2567	.6000
	30	.256	.2531	.5990	.2556	.6000
	40	.255	.2531	.5992	.2550	.6000
	60	.254	.2530	.5994	.2545	.6000
	120	.254	.2530	.5996	.2539	.6000
$t_{.90}$	1	3.078	1.7878	.8377	3.0777	.9000
	2	1.886	2.1065	.9151	1.8764	.8993
	3	1.638	1.6292	.8991	1.6383	.9001
	4	1.533	1.5092	.8971	1.5347	.9002
	5	1.476	1.4420	.8969	1.4772	.9002
	10	1.372	1.3581	.8979	1.3726	.9001
	15	1.341	1.3311	.8985	1.3408	.9000
	20	1.325	1.3182	.8988	1.3255	.9000
	30	1.310	1.3057	.8992	1.3105	.9000
	40	1.303	1.2996	.8994	1.3031	.9000
	60	1.296	1.2936	.8996	1.2958	.9000
	120	1.289	1.2876	.8998	1.2886	.9000
$t_{.995}$	1	63.657	6.6860	.9527	63.6567	.9950
	2	9.925	9.2732	.9943	9.7472	.9948
	3	5.841	5.3978	.9938	5.8223	.9950
	4	4.604	4.4230	.9943	4.5990	.9950
	5	4.032	3.9585	.9946	4.0299	.9950
	10	3.169	3.1961	.9952	3.1702	.9950
	15	2.947	2.9771	.9953	2.9476	.9950
	20	2.845	2.8726	.9953	2.8460	.9950
	30	2.750	2.7712	.9953	2.7504	.9950
	40	2.704	2.7215	.9952	2.7047	.9950
	60	2.660	2.6724	.9952	2.6604	.9950
	120	2.617	2.6240	.9951	2.6175	.9950

* [Ref. 2: p. 464]

SELECTED F INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM	v_1	v_2	TABLED VALUE*	TYPE I APPROXIMATE PERCENTILE	TYPE I ACTUAL PROBABILITY	TYPE II APPROXIMATE PERCENTILE	TYPE II ACTUAL PROBABILITY
$F_{.05}$	1	1	.0062	-	-	.00619	.0500
		2	.0050	-	-	.00392	.0443
		5	.0043	-	-	.00391	.0475
		15	.0041	-	-	.00391	.0490
		30	.0040	-	-	.00391	.0495
		120	.0039	-	-	.00391	.0498
$F_{.05}$	5	1	.151	-	-	.1515	.0501
		2	.173	.1340	.0315	.1611	.0442
		5	.198	.1949	.0495	.1980	.0500
		15	.216	.2110	.0474	.2165	.0500
		30	.222	.2157	.0469	.2223	.0500
		120	.227	.2195	.0464	.2272	.0499
$F_{.05}$	15	1	.220	-	-	.2190	.0495
		2	.272	.2054	.0235	.2435	.0378
		5	.345	.3432	.0489	.3446	.0500
		15	.416	.4157	.0498	.4161	.0500
		30	.445	.4442	.0496	.4451	.0500
		120	.473	.4713	.0492	.4730	.0500
$F_{.05}$	30	1	.240	-	-	.2388	.0496
		2	.302	.2260	.0207	.2671	.0354
		5	.395	.3909	.0483	.3945	.0499
		15	.496	.4962	.0499	.4963	.0500
		30	.543	.5431	.0499	.5432	.0500
		120	.594	.5935	.0497	.5940	.0500
$F_{.05}$	120	1	.255	-	-	.2547	.0498
		2	.326	.2421	.0184	.2855	.0332
		5	.437	.4310	.0474	.4364	.0498
		15	.571	.5705	.0496	.5713	.0500
		30	.644	.6431	.0499	.6434	.0500
		120	.740	.7397	.0500	.7397	.0500

* [Ref. 2: pp. 472-485]

SELECTED F INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM		TABLED VALUE*	TYPE I		TYPE II	
			APPROXIMATE PERCENTILE	ACTUAL PROBABILITY	APPROXIMATE PERCENTILE	ACTUAL PROBABILITY
v_1	v_2					
$F_{.995}$ 1	1	16200	-	-	16210.7	.9950
	2	198	-	-	135.65	.9925
	5	22.8	-	-	21.125	.9941
	15	10.8	-	-	11.063	.9954
	30	9.18	-	-	9.361	.9954
	120	8.18	-	-	8.233	.9951
$F_{.995}$ 5	1	23100	-	-	25615.1	.9953
	2	199	554.13	.9982	276.56	.9964
	5	14.9	15.872	.9956	15.008	.9951
	15	5.37	5.409	.9951	5.373	.9950
	30	4.23	4.245	.9951	4.228	.9950
	120	3.55	3.558	.9951	3.549	.9950
$F_{.995}$ 15	1	24600	-	-	25615.2	.9951
	2	199	572.87	.9983	285.06	.9965
	5	13.1	14.009	.9957	13.228	.9951
	15	4.07	4.082	.9951	4.070	.9950
	30	3.01	3.007	.9950	3.006	.9950
	120	2.37	2.372	.9950	2.373	.9950
$F_{.995}$ 30	1	25000	-	-	25615.2	.9951
	2	199	578.74	.9983	287.53	.9965
	5	12.7	13.530	.9957	12.747	.9951
	15	3.69	3.700	.9951	3.687	.9950
	30	2.63	2.629	.9950	2.628	.9950
	120	1.98	1.984	.9950	1.984	.9950
$F_{.995}$ 120	1	25400	-	-	25615.2	.9950
	2	199	583.29	.9983	289.43	.9966
	5	12.3	13.159	.9958	12.373	.9951
	15	3.37	3.387	.9951	3.373	.9950
	30	2.30	2.302	.9950	2.300	.9950
	120	1.61	1.606	.9950	1.606	.9950

* [Ref. 2: pp. 472-485]

COMPUTER LISTINGS

PROGRAM 1 ONE-POPULATION CONFIDENCE INTERVALS

LABEL ADDRESSES

```
001   71  SBR
046   14   D
059   12   B
114   16  A'
132   13   C
164   95   =
180   33  X²
233   19  D'
266   32  X⇌T
282   10  E'
322   11   A
342   15   E
349   17  B'
450   18  C'
464   61  GTO
480   43  RCL
562   42  STO
```

PROGRAM LISTING

```
000   76  LBL
001   71  SBR
002   43  RCL
003   01   01
004   65   ×
005   02   2
006   85   +
007   02   2
008   54   )
009   42  STO
010   20   20
011   43  RCL
012   03   03
013   75   -
014   43  RCL
015   01   01
016   54   )
017   65   ×
018   02   2
019   54   )
020   42  STO
021   21   21
022   71  SBR
023   43  RCL
024   42  STO
025   04   04
026   43  RCL
027   21   21
028   85   +
029   02   2
030   54   )
031   48  EXC
032   20   20
033   75   -
034   02   2
035   54   )
036   42  STO
037   21   21
038   71  SBR
039   43  RCL
040   43  RCL
041   04   04
042   42  STO
043   11   11
044   92  RTN
045   76  LBL
046   14   D
047   25  CLR
048   04   4
049   69  OP
050   17   17
051   29  CP
052   47  CMS
053   91  R/S
054   78  Σ+
055   61  GTO
056   00   00
057   53   53
058   76  LBL
059   12   B
060   29  CP
061   43  RCL
062   11   11
063   22  INV
064   67  EQ
065   00   00
066   69   69
067   71  SBR
068   71  SBR
069   53   (
070   53   (
071   43  RCL
072   01   01
073   85   +
074   01   1
075   54   )
076   65   ×
077   43  RCL
078   11   11
079   55   ÷
080   53   (
081   24  CE
082   85   +
083   53   (
084   43  RCL
085   03   03
086   75   -
087   43  RCL
088   01   01
089   54   )
090   54   )
091   54   )
092   32  X⇌T
093   53   (
094   43  RCL
095   03   03
096   75   -
097   43  RCL
098   01   01
099   85   +
100   01   1
101   54   )
102   65   ×
103   43  RCL
104   13   13
105   55   ÷
```

PROGRAM 1 Continued

```
106  43  RCL
107  01   01
108  85   +
109  01   1
110  54   )
111  35  1/X
112  92  RTN
113  76  LBL
114  16  A'
115  71  SBR
116  95   =
117  32  X:T
118  53   (
119  71  SBR
120  95   =
121  75   -
122  53   (
123  43  RCL
124  08   08
125  65   X
126  02   2
127  54   )
128  54   )
129  94  +/-
130  92  RTN
131  76  LBL
132  13   C
133  29  CP
134  43  RCL
135  11   11
136  22  INV
137  67   EQ
138  01   01
139  49   49
140  43  RCL
141  03   03
142  75   -
143  01   1
144  54   )
145  42  STO
146  19   19
147  71  SBR
148  42  STO
149  43  RCL
150  07   07
151  22  INV
152  67   EQ
153  16  A'
154  79   X̄
155  42  STO
156  08   08
157  22  INV
158  79   X̄
159  42  STO
160  07   07
161  16  A'
162  92  RTN
163  76  LBL
164  95   =
165  43  RCL
166  07   07
167  65   X
168  43  RCL
169  11   11
170  55   ÷
171  43  RCL
172  03   03
173  34  √X
174  85   +
175  43  RCL
176  08   08
177  54   )
178  92  RTN
179  76  LBL
180  33  X^2
181  17  B'
182  43  RCL
183  14   14
184  65   X
185  09   9
186  54   )
187  35  1/X
188  65   X
189  02   2
190  54   )
191  42  STO
192  15   15
193  34  √X
194  65   X
195  43  RCL
196  11   11
197  54   )
198  42  STO
199  13   13
200  94  +/-
201  85   +
202  01   1
203  75   -
204  43  RCL
205  15   15
206  54   )
207  45  Y^X
208  03   3
209  65   X
210  43  RCL
211  14   14
212  54   )
213  42  STO
214  11   11
215  43  RCL
216  13   13
217  85   +
218  01   1
219  75   -
220  43  RCL
221  15   15
222  54   )
223  45  Y^X
224  03   3
225  65   X
226  43  RCL
227  14   14
228  54   )
229  42  STO
230  13   13
231  92  RTN
232  76  LBL
233  19  D'
234  29  CP
235  43  RCL
236  12   12
237  22  INV
238  67   EQ
239  02   02
240  51   51
241  53   (
242  69  OP
243  11   11
244  65   X
245  43  RCL
246  03   03
247  54   )
248  42  STO
249  12   12
```

PROGRAM 1 Continued

```
250  29  CP
251  43  RCL
252  13   13
253  22  INV
254  67   EQ
255  32  X:T
256  43  RCL
257  03   03
258  75   -
259  01   1
260  54   )
261  42  STO
262  14   14
263  71  SBR
264  33  X²
265  76  LBL
266  32  X:T
267  43  RCL
268  12   12
269  55   ÷
270  43  RCL
271  11   11
272  54   )
273  32  X:T
274  43  RCL
275  12   12
276  55   ÷
277  43  RCL
278  13   13
279  54   )
280  92  RTN
281  76  LBL
282  10  E'
283  29  CP
284  43  RCL
285  08   08
286  22  INV
287  67   EQ
288  02   02
289  93   93
290  79   x̄
291  42  STO
292  08   08
293  43  RCL
294  08   08
295  65   ×
296  02   2
297  65   ×
298  43  RCL
299  03   03
300  54   )
301  42  STO
302  12   12
303  29  CP
304  43  RCL
305  13   13
306  22  INV
307  67   EQ
308  32  X:T
309  43  RCL
310  03   03
311  65   ×
312  02   2
313  54   )
314  42  STO
315  14   14
316  71  SBR
317  33  X²
318  71  SBR
319  32  X:T
320  92  RTN
321  76  LBL
322  11   A
323  29  CP
324  43  RCL
325  11   11
326  22  INV
327  67   EQ
328  03   03
329  31   31
330  17  B'
331  43  RCL
332  08   08
333  22  INV
334  67   EQ
335  16  A'
336  79   x̄
337  42  STO
338  08   08
339  16  A'
340  92  RTN
341  76  LBL
342  15   E
343  10  E'
344  35  1/X
345  32  X:T
346  35  1/X
347  92  RTN
348  76  LBL
349  17  B'
350  43  RCL
351  09   09
352  94  +/-
353  85   +
354  01   1
355  54   )
356  33  X²
357  23  LNX
358  94  +/-
359  34  √X
360  42  STO
361  10   10
362  53   (
363  53   (
364  53   (
365  02   2
366  93   .
367  05   5
368  01   1
369  05   5
370  05   5
371  01   1
372  07   7
373  85   +
374  93   .
375  08   8
376  00   0
377  02   2
378  08   8
379  05   5
380  03   3
381  65   ×
382  43  RCL
383  10   10
384  85   +
385  93   .
386  00   0
387  01   1
388  00   0
389  03   3
390  02   2
391  08   8
392  65   ×
393  43  RCL
```

PROGRAM 1 Continued

```
394  10  10
395  33  X²
396  54  )
397  55  ÷
398  53  (
399  01  1
400  85  +
401  01  1
402  93  .
403  04  4
404  03  3
405  02  2
406  07  7
407  08  8
408  08  8
409  65  ×
410  43  RCL
411  10  10
412  85  +
413  93  .
414  01  1
415  08  8
416  09  9
417  02  2
418  06  6
419  09  9
420  65  ×
421  43  RCL
422  10  10
423  33  X²
424  85  +
425  93  .
426  00  0
427  00  0
428  01  1
429  03  3
430  00  0
431  08  8
432  65  ×
433  43  RCL
434  10  10
435  45  Y×
436  03  3
437  54  )
438  54  )
439  75  -
440  43  RCL
441  10  10
442  54  )
443  42  STO
444  13  13
445  94  +/-
446  42  STO
447  11  11
448  92  RTN
449  76  LBL
450  18  C'
451  29  CP
452  43  RCL
453  11  11
454  22  INV
455  67  EQ
456  61  GTO
457  43  RCL
458  03  03
459  42  STO
460  14  14
461  71  SBR
462  33  X²
463  76  LBL
464  61  GTO
465  43  RCL
466  02  02
467  75  -
468  43  RCL
469  08  08
470  33  X²
471  65  ×
472  43  RCL
473  03  03
474  54  )
475  42  STO
476  12  12
477  61  GTO
478  32  X:T
479  76  LBL
480  43  RCL
481  17  B'
482  33  X²
483  75  -
484  03  3
485  54  )
486  55  ÷
487  06  6
488  54  )
489  42  STO
490  28  28
491  43  RCL
492  20  20
493  75  -
494  01  1
495  54  )
496  35  1/X
497  42  STO
498  27  27
499  85  +
500  53  (
501  43  RCL
502  21  21
503  75  -
504  01  1
505  54  )
506  35  1/X
507  22  INV
508  44  SUM
509  27  27
510  54  )
511  35  1/X
512  65  ×
513  02  2
514  54  )
515  42  STO
516  24  24
517  85  +
518  43  RCL
519  28  28
520  54  )
521  34  √X
522  65  ×
523  43  RCL
524  11  11
525  55  ÷
526  43  RCL
527  24  24
528  54  )
529  75  -
530  53  (
531  43  RCL
532  27  27
533  65  ×
534  53  (
535  43  RCL
536  28  28
537  85  +
```

PROGRAM 1 Continued

538	05	5
539	55	÷
540	06	6
541	75	-
542	02	2
543	55	÷
544	53	(
545	03	3
546	65	×
547	43	RCL
548	24	24
549	54	)
550	54	)
551	54	)
552	54	)
553	65	×
554	02	2
555	54	)
556	22	INV
557	23	LNX
558	42	STD
559	13	13
560	92	RTN
561	76	LBL
562	42	STD
563	43	RCL
564	19	19
565	53	(
566	01	1
567	94	+/-
568	85	+
569	53	(
570	01	1
571	85	+
572	01	1
573	00	0
574	55	÷
575	53	(
576	03	3
577	65	×
578	53	(
579	43	RCL
580	19	19
581	75	-
582	01	1
583	93	.
584	05	5
585	07	7
586	54	)
587	54	)
588	54	)
589	34	√X
590	54	)
591	55	÷
592	05	5
593	54	)
594	42	STD
595	28	28
596	17	B'
597	33	X²
598	65	×
599	43	RCL
600	28	28
601	85	+
602	01	1
603	54	)
604	49	PRD
605	11	11
606	43	RCL
607	11	11
608	92	RTN

END PROGRAM 1

PROGRAM 2 TWO-POPULATION CONFIDENCE INTERVALS

LABEL ADDRESSES

```
001   19  D'
026   61  GTO
084   95   =
096   13   C
158   16  A'
175   81  RST
232   17  B'
331   12   B
398   10  E'
424   15   E
457   14   D
472   71  SBR
487   52  EE
505   11   A
539   42  STO
634   43  RCL
```

PROGRAM LISTING

```
000   76  LBL
001   19  D'
002   43  RCL
003   01   01
004   42  STO
005   13   13
006   43  RCL
007   02   02
008   42  STO
009   14   14
010   43  RCL
011   03   03
012   42  STO
013   15   15
014   79   x̄
015   42  STO
016   18   18
017   22  INV
018   79   x̄
019   33  X²
020   42  STO
021   17   17
022   61  GTO
023   04   04
024   62   62
025   76  LBL
026   61  GTO
027   79   x̄
028   42  STO
029   08   08
030   22  INV
031   79   x̄
032   33  X²
033   42  STO
034   07   07
035   43  RCL
036   13   13
037   42  STO
038   04   04
039   43  RCL
040   14   14
041   42  STO
042   05   05
043   43  RCL
044   15   15
045   75   -
046   01   1
047   54   )
048   65   ×
049   43  RCL
050   17   17
051   85   +
052   53   (
053   53   (
054   43  RCL
055   03   03
056   75   -
057   01   1
058   54   )
059   65   ×
060   43  RCL
061   07   07
062   54   )
063   54   )
064   55   ÷
065   53   (
066   43  RCL
067   15   15
068   85   +
069   43  RCL
070   03   03
071   75   -
072   02   2
073   54   )
074   42  STO
075   19   19
076   54   )
077   34  √X
078   42  STO
079   23   23
080   43  RCL
081   19   19
082   92  RTN
083   76  LBL
084   95   =
085   43  RCL
086   12   12
087   65   ×
088   43  RCL
089   11   11
090   85   +
091   43  RCL
092   10   10
093   54   )
094   92  RTN
095   76  LBL
096   13   C
097   29  CP
098   43  RCL
099   10   10
100   67   EQ
101   01   01
102   27   27
103   43  RCL
104   15   15
105   67   EQ
106   01   01
107   50   50
108   43  RCL
109   16   16
110   67   EQ
111   01   01
112   35   35
113   85   +
114   43  RCL
115   26   26
116   54   )
117   55   ÷
118   43  RCL
119   19   19
120   54   )
121   34  √X
```

PROGRAM 2 Continued

122	42	STO
123	23	23
124	61	GTO
125	01	01
126	35	35
127	43	RCL
128	18	18
129	75	-
130	43	RCL
131	08	08
132	54	)
133	42	STO
134	10	10
135	43	RCL
136	15	15
137	35	1/X
138	85	+
139	43	RCL
140	03	03
141	35	1/X
142	54	)
143	34	√X
144	65	×
145	43	RCL
146	23	23
147	54	)
148	42	STO
149	12	12
150	43	RCL
151	11	11
152	22	INV
153	67	EQ
154	16	A'
155	71	SBR
156	43	RCL
157	76	LBL
158	16	A'
159	71	SBR
160	95	=
161	32	X:T
162	71	SBR
163	95	=
164	75	-
165	53	(
166	43	RCL
167	10	10
168	65	×
169	02	2
170	54	)
171	54	)
172	94	+/-
173	92	RTN
174	76	LBL
175	81	RST
176	43	RCL
177	04	04
178	75	-
179	43	RCL
180	01	01
181	54	)
182	55	÷
183	43	RCL
184	03	03
185	54	)
186	42	STO
187	10	10
188	43	RCL
189	05	05
190	85	+
191	43	RCL
192	02	02
193	75	-
194	02	2
195	65	×
196	43	RCL
197	06	06
198	54	)
199	54	)
200	75	-
201	43	RCL
202	03	03
203	65	×
204	43	RCL
205	10	10
206	33	X²
207	54	)
208	55	÷
209	43	RCL
210	03	03
211	54	)
212	34	√X
213	42	STO
214	23	23
215	55	÷
216	53	(
217	43	RCL
218	03	03
219	75	-
220	01	1
221	54	)
222	42	STO
223	19	19
224	34	√X
225	54	)
226	42	STO
227	12	12
228	43	RCL
229	19	19
230	92	RTN
231	76	LBL
232	17	B'
233	43	RCL
234	09	09
235	94	+/-
236	85	+
237	01	1
238	54	)
239	33	X²
240	23	LNX
241	94	+/-
242	34	√X
243	42	STO
244	29	29
245	53	(
246	53	(
247	53	(
248	02	2
249	93	.
250	05	5
251	01	1
252	05	5
253	05	5
254	01	1
255	07	7
256	85	+
257	93	.
258	08	8
259	00	0
260	02	2
261	08	8
262	05	5
263	03	3
264	65	×
265	43	RCL

PROGRAM 2 Continued

266	29	29
267	85	+
268	93	.
269	00	0
270	01	1
271	00	0
272	03	3
273	02	2
274	08	8
275	65	×
276	43	RCL
277	29	29
278	33	X^2
279	54	)
280	55	÷
281	53	(
282	01	1
283	85	+
284	01	1
285	93	.
286	04	4
287	03	3
288	02	2
289	07	7
290	08	8
291	08	8
292	65	×
293	43	RCL
294	29	29
295	85	+
296	93	.
297	01	1
298	08	8
299	09	9
300	02	2
301	06	6
302	09	9
303	65	×
304	43	RCL
305	29	29
306	33	X^2
307	85	+
308	93	.
309	00	0
310	00	0
311	01	1
312	03	3
313	00	0
314	08	8
315	65	×
316	43	RCL
317	29	29
318	45	Y^X
319	03	3
320	54	)
321	54	)
322	94	+/-
323	85	+
324	43	RCL
325	29	29
326	54	)
327	42	STO
328	11	11
329	92	RTN
330	76	LBL
331	12	B
332	29	CP
333	43	RCL
334	11	11
335	22	INV
336	67	EQ
337	03	03
338	40	40
339	17	B'
340	43	RCL
341	01	01
342	55	÷
343	43	RCL
344	03	03
345	54	)
346	42	STO
347	18	18
348	94	+/-
349	85	+
350	01	1
351	54	)
352	65	×
353	43	RCL
354	18	18
355	55	÷
356	43	RCL
357	03	03
358	54	)
359	42	STO
360	05	05
361	43	RCL
362	02	02
363	55	÷
364	43	RCL
365	04	04
366	54	)
367	42	STO
368	08	08
369	94	+/-
370	85	+
371	01	1
372	54	)
373	65	×
374	43	RCL
375	08	08
376	55	÷
377	43	RCL
378	04	04
379	54	)
380	85	+
381	43	RCL
382	05	05
383	54	)
384	34	√X
385	42	STO
386	12	12
387	43	RCL
388	18	18
389	75	-
390	43	RCL
391	08	08
392	54	)
393	42	STO
394	10	10
395	16	A'
396	92	RTN
397	76	LBL
398	10	E'
399	43	RCL
400	08	08
401	42	STO
402	17	17
403	43	RCL
404	18	18
405	42	STO
406	07	07
407	43	RCL
408	08	08
409	29	CP

PROGRAM 2 Continued

```
410  43  RCL
411  11   11
412  22  INV
413  67   EQ
414  04   04
415  36   36
416  71  SBR
417  52  EE
418  71  SBR
419  42  STO
420  61  GTO
421  04   04
422  36   36
423  76  LBL
424  15   E
425  29  CP
426  43  RCL
427  11   11
428  22  INV
429  67   EQ
430  04   04
431  36   36
432  71  SBR
433  71  SBR
434  71  SBR
435  42  STO
436  43  RCL
437  13   13
438  65   ×
439  43  RCL
440  17   17
441  55   ÷
442  43  RCL
443  07   07
444  54   )
445  32  X:T
446  43  RCL
447  17   17
448  55   ÷
449  43  RCL
450  07   07
451  55   ÷
452  43  RCL
453  11   11
454  54   )
455  92  RTN
456  76  LBL
457  14   D
458  03   3
459  69  OP
460  17   17
461  47  CMS
462  36  PGM
463  01   01
464  71  SBR
465  25  CLR
466  91  R/S
467  78  Σ+
468  61  GTO
469  04   04
470  66   66
471  76  LBL
472  71  SBR
473  43  RCL
474  03   03
475  75   -
476  01   1
477  54   )
478  42  STO
479  21   21
480  75   -
481  01   1
482  54   )
483  42  STO
484  20   20
485  92  RTN
486  76  LBL
487  52  EE
488  43  RCL
489  03   03
490  65   ×
491  02   2
492  54   )
493  42  STO
494  21   21
495  32  X:T
496  43  RCL
497  15   15
498  65   ×
499  02   2
500  54   )
501  42  STO
502  20   20
503  92  RTN
504  76  LBL
505  11   A
506  29  CP
507  43  RCL
508  11   11
509  22  INV
510  67   EQ
511  05   05
512  14   14
513  17  B'
514  43  RCL
515  12   12
516  22  INV
517  67   EQ
518  16  A'
519  43  RCL
520  17   17
521  85   +
522  43  RCL
523  07   07
524  54   )
525  34  ΓX
526  42  STO
527  12   12
528  43  RCL
529  18   18
530  75   -
531  43  RCL
532  08   08
533  54   )
534  42  STO
535  10   10
536  16  A'
537  92  RTN
538  76  LBL
539  42  STO
540  17  B'
541  33  X²
542  75   -
543  03   3
544  54   )
545  55   ÷
546  06   6
547  54   )
548  42  STO
549  28   28
550  43  RCL
551  20   20
552  75   -
553  01   1
```

PROGRAM 2 Continued

```
554  54  )
555  35  1/X
556  42  STO
557  27   27
558  85  +
559  53  (
560  43  RCL
561  21   21
562  75  -
563  01  1
564  54  )
565  35  1/X
566  22  INV
567  44  SUM
568  27   27
569  54  )
570  35  1/X
571  65  ×
572  02  2
573  54  )
574  42  STO
575  24   24
576  85  +
577  43  RCL
578  28   28
579  54  )
580  34  ΓX
581  65  ×
582  43  RCL
583  11   11
584  55  ÷
585  43  RCL
586  24   24
587  54  )
588  42  STO
589  11   11
590  75  -
591  53  (
592  43  RCL
593  27   27
594  65  ×
595  53  (
596  43  RCL
597  28   28
598  85  +
599  05  5
600  55  ÷
601  06  6
602  75  -
603  02  2
604  55  ÷
605  53  (
606  03  3
607  65  ×
608  43  RCL
609  24   24
610  54  )
611  54  )
612  54  )
613  44  SUM
614  11   11
615  54  )
616  65  ×
617  02  2
618  54  )
619  22  INV
620  23  LNX
621  48  EXC
622  11   11
623  65  ×
624  02  2
625  54  )
626  22  INV
627  23  LNX
628  42  STO
629  13   13
630  43  RCL
631  11   11
632  92  RTN
633  76  LBL
634  43  RCL
635  43  RCL
636  19   19
637  53  (
638  01  1
639  94  +/-
640  85  +
641  53  (
642  01  1
643  85  +
644  01  1
645  00  0
646  55  ÷
647  53  (
648  03  3
649  65  ×
650  53  (
651  43  RCL
652  19   19
653  75  -
654  01  1
655  93  .
656  05  5
657  07  7
658  54  )
659  54  )
660  54  )
661  34  ΓX
662  54  )
663  55  ÷
664  05  5
665  54  )
666  42  STO
667  28   28
668  17  B'
669  33  X²
670  65  ×
671  43  RCL
672  28   28
673  85  +
674  01  1
675  54  )
676  49  PRD
677  11   11
678  43  RCL
679  11   11
680  92  RTN
```

END PROGRAM 2

PROGRAM 3 ONE-POPULATION HYPOTHESIS TESTS

LABEL ADDRESSES

001	14	D
007	10	E'
025	18	C'
053	65	×
071	55	÷
086	30	TAN
106	25	CLR
124	38	SIN
137	39	COS
146	22	INV
150	80	GRD
159	15	E
194	12	B
229	23	LNX
263	44	SUM
286	24	CE
306	13	C
375	85	+
400	75	-
417	16	A'
452	11	A
484	57	ENG
501	17	B'
530	58	FIX
546	59	INT
569	28	LOG
596	19	D'

PROGRAM LISTING

000	76	LBL
001	14	D
002	91	R/S
003	78	Σ+
004	61	GTO
005	14	D
006	76	LBL
007	10	E'
008	25	CLR
009	03	3
010	69	OP
011	17	17
012	47	CMS
013	29	CP
014	91	R/S
015	42	STO
016	08	08
017	91	R/S
018	42	STO
019	11	11
020	91	R/S
021	42	STO
022	00	00
023	92	RTN
024	76	LBL
025	18	C'
026	06	6
027	05	5
028	32	X:T
029	43	RCL
030	06	06
031	77	GE
032	30	TAN
033	43	RCL
034	00	00
035	32	X:T
036	01	1
037	67	EQ
038	65	×
039	94	+/-
040	67	EQ
041	55	÷
042	93	.
043	05	5
044	49	PRD
045	11	11
046	71	SBR
047	65	×
048	29	CP
049	67	EQ
050	55	÷
051	92	RTN
052	76	LBL
053	65	×
054	43	RCL
055	06	06
056	36	PGM
057	21	21
058	11	A
059	43	RCL
060	12	12
061	36	PGM
062	21	21
063	13	C
064	94	+/-
065	85	+
066	01	1
067	54	)
068	61	GTO
069	80	GRD
070	76	LBL
071	55	÷
072	43	RCL
073	06	06
074	36	PGM
075	21	21
076	11	A
077	43	RCL
078	12	12
079	36	PGM
080	21	21
081	13	C
082	61	GTO
083	80	GRD
084	92	RTN
085	76	LBL
086	30	TAN
087	43	RCL
088	06	06
089	65	×
090	02	2
091	54	)
092	34	√X
093	35	1/X
094	65	×
095	53	(
096	43	RCL
097	12	12
098	75	-
099	43	RCL
100	06	06
101	54	)
102	54	)
103	42	STO
104	12	12
105	76	LBL
106	25	CLR
107	43	RCL
108	00	00
109	32	X:T
110	00	0
111	67	EQ

PROGRAM 3 Continued

112	38	SIN
113	01	1
114	67	EQ
115	39	COS
116	43	RCL
117	12	12
118	36	PGM
119	19	19
120	12	B
121	61	GTO
122	80	GRD
123	76	LBL
124	38	SIN
125	43	RCL
126	12	12
127	36	PGM
128	19	19
129	14	D
130	94	+/-
131	85	+
132	01	1
133	54	)
134	61	GTO
135	80	GRD
136	76	LBL
137	39	COS
138	43	RCL
139	12	12
140	36	PGM
141	19	19
142	13	C
143	61	GTO
144	80	GRD
145	76	LBL
146	22	INV
147	01	1
148	92	RTN
149	76	LBL
150	80	GRD
151	32	X:T
152	43	RCL
153	11	11
154	77	GE
155	22	INV
156	00	0
157	92	RTN
158	76	LBL
159	15	E
160	43	RCL
161	10	10
162	32	X:T
163	00	0
164	22	INV
165	67	EQ
166	01	01
167	71	71
168	79	x̄
169	42	STO
170	10	10
171	43	RCL
172	10	10
173	65	×
174	02	2
175	65	×
176	43	RCL
177	03	03
178	55	÷
179	43	RCL
180	08	08
181	54	)
182	42	STO
183	12	12
184	43	RCL
185	03	03
186	65	×
187	02	2
188	54	)
189	42	STO
190	06	06
191	61	GTO
192	18	C'
193	76	LBL
194	12	B
195	03	3
196	00	0
197	32	X:T
198	43	RCL
199	03	03
200	77	GE
201	23	LNX
202	43	RCL
203	00	00
204	32	X:T
205	01	1
206	67	EQ
207	44	SUM
208	01	1
209	94	+/-
210	67	EQ
211	24	CE
212	93	.
213	05	5
214	49	PRD
215	11	11
216	71	SBR
217	44	SUM
218	29	CP
219	67	EQ
220	24	CE
221	48	EXC
222	01	01
223	42	STO
224	12	12
225	43	RCL
226	01	01
227	92	RTN
228	76	LBL
229	23	LNX
230	43	RCL
231	08	08
232	94	+/-
233	85	+
234	01	1
235	54	)
236	65	×
237	43	RCL
238	08	08
239	65	×
240	43	RCL
241	03	03
242	54	)
243	34	√X
244	35	1/X
245	65	×
246	53	(
247	43	RCL
248	08	08
249	65	×
250	43	RCL
251	03	03
252	94	+/-
253	85	+
254	43	RCL
255	01	01

PROGRAM 3 Continued

256	54	)
257	54	)
258	42	STO
259	12	12
260	61	GTO
261	25	CLR
262	76	LBL
263	44	SUM
264	43	RCL
265	03	03
266	36	PGM
267	20	20
268	11	A
269	43	RCL
270	08	08
271	36	PGM
272	20	20
273	12	B
274	43	RCL
275	01	01
276	75	-
277	01	1
278	54	)
279	36	PGM
280	20	20
281	15	E
282	61	GTO
283	80	GRD
284	92	RTN
285	76	LBL
286	24	CE
287	43	RCL
288	03	03
289	36	PGM
290	20	20
291	11	A
292	43	RCL
293	08	08
294	36	PGM
295	20	20
296	12	B
297	43	RCL
298	01	01
299	36	PGM
300	20	20
301	14	D
302	61	GTO
303	80	GRD
304	92	RTN
305	76	LBL
306	13	C
307	43	RCL
308	10	10
309	32	X:T
310	00	0
311	22	INV
312	67	EQ
313	03	03
314	22	22
315	79	x̄
316	42	STO
317	10	10
318	22	INV
319	79	x̄
320	42	STO
321	14	14
322	43	RCL
323	10	10
324	75	-
325	43	RCL
326	08	08
327	54	)
328	65	×
329	43	RCL
330	03	03
331	34	√X
332	55	÷
333	43	RCL
334	14	14
335	54	)
336	42	STO
337	12	12
338	03	3
339	01	1
340	32	X:T
341	43	RCL
342	03	03
343	77	GE
344	25	CLR
345	43	RCL
346	00	00
347	32	X:T
348	00	0
349	67	EQ
350	85	+
351	01	1
352	94	+/-
353	67	EQ
354	75	-
355	43	RCL
356	03	03
357	75	-
358	01	1
359	54	)
360	36	PGM
361	21	21
362	11	A
363	43	RCL
364	12	12
365	36	PGM
366	21	21
367	15	E
368	94	+/-
369	85	+
370	01	1
371	54	)
372	61	GTO
373	80	GRD
374	76	LBL
375	85	+
376	43	RCL
377	03	03
378	75	-
379	01	1
380	54	)
381	36	PGM
382	21	21
383	11	A
384	43	RCL
385	12	12
386	50	I×I
387	36	PGM
388	21	21
389	15	E
390	94	+/-
391	85	+
392	01	1
393	54	)
394	65	×
395	02	2
396	54	)
397	61	GTO
398	80	GRD
399	76	LBL

PROGRAM 3 Continued

400	75	-
401	43	RCL
402	03	03
403	75	-
404	01	1
405	54	)
406	36	PGM
407	21	21
408	11	A
409	43	RCL
410	12	12
411	36	PGM
412	21	21
413	15	E
414	61	GTO
415	80	GRD
416	76	LBL
417	16	A'
418	43	RCL
419	10	10
420	32	X:T
421	00	0
422	22	INV
423	67	EQ
424	04	04
425	34	34
426	69	OP
427	11	11
428	65	×
429	43	RCL
430	03	03
431	54	)
432	42	STO
433	10	10
434	43	RCL
435	10	10
436	55	÷
437	43	RCL
438	08	08
439	54	)
440	42	STO
441	12	12
442	43	RCL
443	03	03
444	75	-
445	01	1
446	54	)
447	42	STO
448	06	06
449	61	GTO
450	18	C'
451	76	LBL
452	11	A
453	43	RCL
454	10	10
455	32	X:T
456	00	0
457	22	INV
458	67	EQ
459	04	04
460	64	64
461	79	x̄
462	42	STO
463	10	10
464	43	RCL
465	10	10
466	75	-
467	43	RCL
468	08	08
469	54	)
470	65	×
471	43	RCL
472	03	03
473	34	ΓX
474	55	÷
475	43	RCL
476	07	07
477	54	)
478	54	)
479	42	STO
480	12	12
481	61	GTO
482	25	CLR
483	76	LBL
484	57	ENG
485	65	×
486	02	2
487	54	)
488	36	PGM
489	21	21
490	11	A
491	43	RCL
492	02	02
493	65	×
494	02	2
495	54	)
496	36	PGM
497	21	21
498	13	C
499	92	RTN
500	76	LBL
501	17	B'
502	03	3
503	00	0
504	32	X:T
505	43	RCL
506	01	01
507	77	GE
508	28	LOG
509	43	RCL
510	00	00
511	32	X:T
512	01	1
513	67	EQ
514	58	FIX
515	01	1
516	94	+/-
517	67	EQ
518	59	INT
519	93	.
520	05	5
521	49	PRD
522	11	11
523	71	SBR
524	58	FIX
525	29	CP
526	67	EQ
527	59	INT
528	92	RTN
529	76	LBL
530	58	FIX
531	43	RCL
532	03	03
533	65	×
534	43	RCL
535	08	08
536	54	)
537	42	STO
538	02	02
539	43	RCL
540	01	01
541	71	SBR
542	57	ENG
543	61	GTO

PROGRAM 3 Continued

544	80	GRD
545	76	LBL
546	59	INT
547	43	RCL
548	03	03
549	65	×
550	43	RCL
551	08	08
552	54	)
553	42	STO
554	02	02
555	43	RCL
556	01	01
557	85	+
558	01	1
559	54	)
560	71	SBR
561	57	ENG
562	94	+/-
563	85	+
564	01	1
565	54	)
566	61	GTO
567	80	GRD
568	76	LBL
569	28	LOG
570	43	RCL
571	08	08
572	65	×
573	43	RCL
574	03	03
575	54	)
576	34	√X
577	35	1/X
578	65	×
579	53	(
580	43	RCL
581	08	08
582	65	×
583	43	RCL
584	03	03
585	94	+/-
586	85	+
587	43	RCL
588	01	01
589	54	)
590	54	)
591	42	STO
592	12	12
593	61	GTO
594	25	CLR
595	76	LBL
596	19	D'
597	43	RCL
598	02	02
599	85	+
600	53	(
601	43	RCL
602	10	10
603	33	X^2
604	65	×
605	43	RCL
606	03	03
607	54	)
608	75	-
609	53	(
610	02	2
611	65	×
612	43	RCL
613	10	10
614	65	×
615	43	RCL
616	01	01
617	54	)
618	54	)
619	55	÷
620	43	RCL
621	08	08
622	54	)
623	42	STO
624	12	12
625	43	RCL
626	03	03
627	42	STO
628	06	06
629	71	SBR
630	18	C'
631	92	RTN
632	00	0
633	10	E'

END PROGRAM 3

PROGRAM 4 TWO-POPULATION HYPOTHESIS TESTS

LABEL ADDRESSES

002	61	GTO
031	33	X^2
050	10	E'
066	48	EXC
087	42	STO
093	43	RCL
100	80	GRD
113	22	INV
117	25	CLR
135	38	SIN
148	39	COS
157	60	DEG
190	85	+
207	75	-
216	17	B'
232	13	C
318	19	D'
357	15	E
396	12	B
458	81	RST
483	18	C'
567	16	A'
596	11	A
627	14	D

PROGRAM LISTING

000	92	RTN
001	76	LBL
002	61	GTO
003	43	RCL
004	01	01
005	42	STO
006	27	27
007	43	RCL
008	02	02
009	42	STO
010	26	26
011	43	RCL
012	03	03
013	42	STO
014	15	15
015	42	STO
016	28	28
017	79	$\bar{X}$
018	42	STO
019	14	14
020	22	INV
021	79	$\bar{X}$
022	33	X^2
023	42	STO
024	09	09
025	86	STF
026	02	02
027	61	GTO
028	06	06
029	45	45
030	76	LBL
031	33	X^2
032	79	$\bar{X}$
033	42	STO
034	08	08
035	22	INV
036	79	$\bar{X}$
037	33	X^2
038	42	STO
039	07	07
040	43	RCL
041	27	27
042	42	STO
043	04	04
044	43	RCL
045	26	26
046	42	STO
047	05	05
048	92	RTN
049	76	LBL
050	10	E'
051	03	3
052	69	OP
053	17	17
054	47	CMS
055	29	CP
056	25	CLR
057	91	R/S
058	42	STO
059	11	11
060	91	R/S
061	42	STO
062	00	00
063	81	RST
064	92	RTN
065	76	LBL
066	48	EXC
067	43	RCL
068	00	00
069	32	X:T
070	01	1
071	67	EQ
072	42	STO
073	94	+/-
074	67	EQ
075	43	RCL
076	93	.
077	05	5
078	49	PRD
079	11	11
080	71	SBR
081	42	STO
082	29	CP
083	67	EQ
084	43	RCL
085	92	RTN
086	76	LBL
087	42	STO
088	43	RCL
089	26	26
090	61	GTO
091	80	GRD
092	76	LBL
093	43	RCL
094	01	1
095	75	-
096	43	RCL
097	26	26
098	54	)
099	76	LBL
100	80	GRD
101	32	X:T
102	43	RCL
103	28	28
104	42	STO
105	15	15
106	43	RCL
107	11	11
108	77	GE
109	22	INV
110	00	0
111	92	RTN
112	76	LBL
113	22	INV
114	01	1

PROGRAM 4 Continued

115	92	RTN
116	76	LBL
117	25	CLR
118	43	RCL
119	00	00
120	32	X:T
121	00	0
122	67	EQ
123	38	SIN
124	01	1
125	67	EQ
126	39	COS
127	43	RCL
128	10	10
129	36	PGM
130	19	19
131	12	B
132	61	GTO
133	80	GRD
134	76	LBL
135	38	SIN
136	43	RCL
137	10	10
138	36	PGM
139	19	19
140	14	D
141	94	+/-
142	85	+
143	01	1
144	54	)
145	61	GTO
146	80	GRD
147	76	LBL
148	39	COS
149	43	RCL
150	10	10
151	36	PGM
152	19	19
153	13	C
154	61	GTO
155	80	GRD
156	76	LBL
157	60	DEG
158	03	3
159	00	0
160	32	X:T
161	43	RCL
162	25	25
163	77	GE
164	25	CLR
165	36	PGM
166	21	21
167	11	A
168	43	RCL
169	00	00
170	32	X:T
171	00	0
172	67	EQ
173	85	+
174	01	1
175	94	+/-
176	67	EQ
177	75	-
178	43	RCL
179	10	10
180	36	PGM
181	21	21
182	15	E
183	94	+/-
184	85	+
185	01	1
186	54	)
187	61	GTO
188	80	GRD
189	76	LBL
190	85	+
191	43	RCL
192	10	10
193	50	I×I
194	36	PGM
195	21	21
196	15	E
197	94	+/-
198	85	+
199	01	1
200	54	)
201	65	×
202	02	2
203	54	)
204	61	GTO
205	80	GRD
206	76	LBL
207	75	-
208	43	RCL
209	10	10
210	36	PGM
211	21	21
212	15	E
213	61	GTO
214	80	GRD
215	76	LBL
216	17	B'
217	43	RCL
218	10	10
219	32	X:T
220	00	0
221	22	INV
222	67	EQ
223	60	DEG
224	36	PGM
225	13	13
226	11	A
227	42	STO
228	10	10
229	61	GTO
230	60	DEG
231	76	LBL
232	13	C
233	43	RCL
234	02	02
235	32	X:T
236	00	0
237	22	INV
238	67	EQ
239	03	03
240	06	06
241	43	RCL
242	15	15
243	42	STO
244	28	28
245	85	+
246	43	RCL
247	03	03
248	75	-
249	02	2
250	54	)
251	42	STO
252	25	25
253	35	1/X
254	65	×
255	53	(
256	43	RCL
257	09	09
258	65	×

PROGRAM 4 Continued

```
259  53  (
260  43  RCL
261  15  15
262  75  -
263  01  1
264  54  )
265  85  +
266  43  RCL
267  07  07
268  65  ×
269  53  (
270  43  RCL
271  03  03
272  75  -
273  01  1
274  54  )
275  54  )
276  54  )
277  34  ΓX
278  42  STO
279  29  29
280  65  ×
281  53  (
282  43  RCL
283  15  15
284  35  1/X
285  85  +
286  43  RCL
287  03  03
288  35  1/X
289  54  )
290  34  ΓX
291  54  )
292  35  1/X
293  65  ×
294  53  (
295  43  RCL
296  14  14
297  75  -
298  43  RCL
299  08  08
300  54  )
301  54  )
302  42  STO
303  10  10
304  61  GTO
305  60  DEG
306  36  PGM
307  13  13
308  16  A'
309  42  STO
310  10  10
311  43  RCL
312  23  23
313  42  STO
314  29  29
315  61  GTO
316  60  DEG
317  76  LBL
318  19  D'
319  43  RCL
320  15  15
321  42  STO
322  28  28
323  75  -
324  01  1
325  54  )
326  42  STO
327  15  15
328  36  PGM
329  22  22
330  11  A
331  43  RCL
332  03  03
333  75  -
334  01  1
335  54  )
336  42  STO
337  16  16
338  36  PGM
339  22  22
340  12  B
341  43  RCL
342  09  09
343  55  ÷
344  43  RCL
345  07  07
346  54  )
347  42  STO
348  10  10
349  36  PGM
350  22  22
351  13  C
352  42  STO
353  26  26
354  61  GTO
355  48  EXC
356  76  LBL
357  15  E
358  43  RCL
359  15  15
360  42  STO
361  28  28
362  65  ×
363  02  2
364  54  )
365  42  STO
366  15  15
367  36  PGM
368  22  22
369  11  A
370  43  RCL
371  03  03
372  65  ×
373  02  2
374  54  )
375  42  STO
376  16  16
377  36  PGM
378  22  22
379  12  B
380  43  RCL
381  14  14
382  55  ÷
383  43  RCL
384  08  08
385  54  )
386  42  STO
387  10  10
388  36  PGM
389  22  22
390  13  C
391  42  STO
392  26  26
393  61  GTO
394  48  EXC
395  76  LBL
396  12  B
397  43  RCL
398  01  01
399  85  +
400  43  RCL
401  04  04
402  54  )
```

PROGRAM 4 Continued

```
403  55  ÷        451  54  )        499  07  07
404  53  (        452  54  )        500  55  ÷
405  43  RCL      453  42  STO      501  43  RCL
406  15  15       454  10  10       502  03  03
407  85  +        455  61  GTO      503  54  )
408  43  RCL      456  25  CLR      504  42  STO
409  03  03       457  76  LBL      505  13  13
410  54  )        458  81  RST      506  54  )
411  54  )        459  43  RCL      507  34  √X
412  42  STO      460  04  04       508  42  STO
413  18  18       461  75  -        509  29  29
414  94  +/-      462  43  RCL      510  35  1/X
415  85  +        463  01  01       511  65  ×
416  01  1        464  54  )        512  53  (
417  54  )        465  42  STO      513  43  RCL
418  65  ×        466  12  12       514  14  14
419  43  RCL      467  43  RCL      515  75  -
420  18  18       468  05  05       516  43  RCL
421  65  ×        469  85  +        517  08  08
422  53  (        470  43  RCL      518  54  )
423  43  RCL      471  02  02       519  54  )
424  15  15       472  75  -        520  42  STO
425  35  1/X      473  02  2        521  10  10
426  85  +        474  65  ×        522  43  RCL
427  43  RCL      475  43  RCL      523  12  12
428  03  03       476  06  06       524  33  X²
429  35  1/X      477  54  )        525  55  ÷
430  54  )        478  42  STO      526  53  (
431  54  )        479  13  13       527  43  RCL
432  34  √X       480  92  RTN      528  15  15
433  42  STO      481  00  0        529  85  +
434  29  29       482  76  LBL      530  01  1
435  35  1/X      483  18  C'       531  54  )
436  65  ×        484  43  RCL      532  85  +
437  53  (        485  15  15       533  53  (
438  43  RCL      486  42  STO      534  53  (
439  04  04       487  28  28       535  43  RCL
440  55  ÷        488  43  RCL      536  13  13
441  43  RCL      489  09  09       537  33  X²
442  15  15       490  55  ÷        538  55  ÷
443  75  -        491  43  RCL      539  53  (
444  53  (        492  15  15       540  43  RCL
445  43  RCL      493  54  )        541  03  03
446  01  01       494  42  STO      542  85  +
447  55  ÷        495  12  12       543  01  1
448  43  RCL      496  85  +        544  54  )
449  03  03       497  53  (        545  54  )
450  54  )        498  43  RCL      546  54  )
```

PROGRAM 4 Continued

547	54	)
548	35	1/X
549	65	×
550	43	RCL
551	29	29
552	33	X²
553	33	X²
554	54	)
555	75	-
556	01	1
557	93	.
558	05	5
559	54	)
560	59	INT
561	42	STO
562	25	25
563	71	SBR
564	60	DEG
565	92	RTN
566	76	LBL
567	16	A'
568	43	RCL
569	03	03
570	75	-
571	02	2
572	54	)
573	42	STO
574	25	25
575	55	÷
576	53	(
577	69	OP
578	13	13
579	33	X²
580	94	+/-
581	85	+
582	01	1
583	54	)
584	54	)
585	34	√X
586	65	×
587	69	OP
588	13	13
589	54	)
590	42	STO
591	10	10
592	71	SBR
593	60	DEG
594	92	RTN
595	76	LBL
596	11	A
597	43	RCL
598	09	09
599	55	÷
600	43	RCL
601	15	15
602	85	+
603	53	(
604	43	RCL
605	07	07
606	55	÷
607	43	RCL
608	03	03
609	54	)
610	54	)
611	34	√X
612	35	1/X
613	65	×
614	53	(
615	43	RCL
616	14	14
617	75	-
618	43	RCL
619	08	08
620	54	)
621	42	STO
622	10	10
623	71	SBR
624	25	CLR
625	92	RTN
626	76	LBL
627	14	D
628	87	IFF
629	01	01
630	61	GTO
631	86	STF
632	01	01
633	87	IFF
634	02	02
635	33	X²
636	36	PGM
637	01	01
638	71	SBR
639	25	CLR
640	91	R/S
641	78	Σ+
642	61	GTO
643	06	06
644	40	40
645	36	PGM
646	01	01
647	71	SBR
648	25	CLR
649	22	INV
650	86	STF
651	01	01
652	91	R/S
653	78	Σ+
654	61	GTO
655	06	06
656	52	52

END PROGRAM 4

PROGRAM 5 NORMAL DISTRIBUTION APPROXIMATION

LABEL ADDRESSES

001	11	A
113	12	B
132	14	D
147	15	E
160	13	C
179	10	E'
278	19	D'

PROGRAM LISTING

000	76	LBL
001	11	A
002	53	(
003	33	X²
004	22	INV
005	23	LNX
006	65	×
007	02	2
008	65	×
009	89	π
010	54	)
011	34	√X
012	35	1/X
013	92	RTN
014	53	(
015	50	I×I
016	65	×
017	93	.
018	02	2
019	03	3
020	01	1
021	06	6
022	04	4
023	01	1
024	09	9
025	85	+
026	01	1
027	54	)
028	35	1/X
029	53	(
030	42	STD
031	25	25
032	49	PRD
033	25	25
034	42	STD
035	26	26
036	65	×
037	93	.
038	03	3
039	01	1
040	09	9
041	03	3
042	08	8
043	01	1
044	05	5
045	03	3
046	75	-
047	93	.
048	03	3
049	05	5
050	06	6
051	05	5
052	06	6
053	03	3
054	07	7
055	08	8
056	02	2
057	65	×
058	43	RCL
059	25	25
060	49	PRD
061	26	26
062	85	+
063	01	1
064	93	.
065	07	7
066	08	8
067	01	1
068	04	4
069	07	7
070	07	7
071	09	9
072	03	3
073	07	7
074	65	×
075	43	RCL
076	26	26
077	75	-
078	01	1
079	93	.
080	08	8
081	02	2
082	01	1
083	02	2
084	05	5
085	05	5
086	09	9
087	07	7
088	08	8
089	65	×
090	43	RCL
091	25	25
092	49	PRD
093	26	26
094	33	X²
095	85	+
096	01	1
097	93	.
098	03	3
099	03	3
100	00	0
101	02	2
102	07	7
103	04	4
104	04	4
105	02	2
106	09	9
107	65	×
108	43	RCL
109	26	26
110	54	)
111	92	RTN
112	76	LBL
113	12	B
114	29	CP
115	77	GE
116	01	01
117	37	37
118	42	STD
119	25	25
120	11	A
121	53	(
122	24	CE
123	65	×
124	43	RCL
125	25	25
126	71	SBR
127	00	00
128	14	14
129	54	)
130	92	RTN
131	76	LBL

PROGRAM 5 Continued

```
132  14  D
133  29  CP
134  77  GE
135  01  01
136  18  18
137  71  SBR
138  01  01
139  18  18
140  53  (
141  94  +/-
142  85  +
143  01  1
144  54  )
145  92  RTN
146  76  LBL
147  15  E
148  71  SBR
149  01  01
150  18  18
151  53  (
152  94  +/-
153  65  ×
154  02  2
155  85  +
156  01  1
157  54  )
158  92  RTN
159  76  LBL
160  13  C
161  42  STO
162  09  09
163  32  X:T
164  93  .
165  05  5
166  22  INV
167  77  GE
168  10  E'
169  32  X:T
170  94  +/-
171  85  +
172  01  1
173  54  )
174  42  STO
175  09  09
176  86  STF
177  01  01
178  76  LBL
179  10  E'
180  43  RCL
181  09  09
182  94  +/-
183  85  +
184  01  1
185  54  )
186  33  X²
187  23  LNX
188  94  +/-
189  34  √X
190  42  STO
191  29  29
192  02  2
193  93  .
194  05  5
195  01  1
196  05  5
197  05  5
198  01  1
199  07  7
200  85  +
201  93  .
202  08  8
203  00  0
204  02  2
205  08  8
206  05  5
207  03  3
208  65  ×
209  43  RCL
210  29  29
211  85  +
212  93  .
213  00  0
214  01  1
215  00  0
216  03  3
217  02  2
218  08  8
219  65  ×
220  43  RCL
221  29  29
222  33  X²
223  54  )
224  55  ÷
225  53  (
226  01  1
227  85  +
228  01  1
229  93  .
230  04  4
231  03  3
232  02  2
233  07  7
234  08  8
235  08  8
236  65  ×
237  43  RCL
238  29  29
239  85  +
240  93  .
241  01  1
242  08  8
243  09  9
244  02  2
245  06  6
246  09  9
247  65  ×
248  43  RCL
249  29  29
250  33  X²
251  85  +
252  93  .
253  00  0
254  00  0
255  01  1
256  03  3
257  00  0
258  08  8
259  65  ×
260  43  RCL
261  29  29
262  45  YX
263  03  3
264  54  )
265  54  )
266  94  +/-
267  85  +
268  43  RCL
269  29  29
270  54  )
271  42  STO
272  11  11
273  87  IFF
274  01  01
275  19  D'
```

PROGRAM 5 Continued

```
276  92 RTN
277  76 LBL
278  19 D'
279  43 RCL
280  09  09
281  94 +/-
282  85  +
283  01  1
284  54  )
285  42 STO
286  09  09
287  22 INV
288  86 STF
289  01  01
290  43 RCL
291  11  11
292  94 +/-
293  42 STO
294  11  11
295  92 RTN
```

END PROGRAM 5

PROGRAM 6 BINOMIAL AND MULTINOMIAL APPROXIMATIONS

LABEL ADDRESSES

```
001   16  A'
010   17  B'
019   11  A
026   12  B
039   13  C
101   14  D
107   15  E
123   18  C'
169   19  D'
227   10  E'
```

PROGRAM LISTING

```
000   76  LBL
001   16  A'
002   43  RCL
003   01   01
004   65   X
005   43  RCL
006   02   02
007   54   )
008   92  RTN
009   76  LBL
010   17  B'
011   16  A'
012   65   X
013   43  RCL
014   03   03
015   54   )
016   34  √X
017   92  RTN
018   76  LBL
019   11   A
020   59  INT
021   50  I×I
022   42  STO
023   01   01
024   92  RTN
025   76  LBL
026   12   B
027   42  STO
028   02   02
029   94  +/-
030   85   +
031   01   1
032   54   )
033   42  STO
034   03   03
035   43  RCL
036   02   02
037   92  RTN
038   76  LBL
039   13   C
040   29  CP
041   22  INV
042   77   GE
043   01   01
044   15   15
045   32  X:T
046   42  STO
047   04   04
048   01   1
049   94  +/-
050   42  STO
051   05   05
052   43  RCL
053   03   03
054   45  Y^X
055   43  RCL
056   01   01
057   54   )
058   42  STO
059   06   06
060   44  SUM
061   04   04
062   01   1
063   44  SUM
064   05   05
065   43  RCL
066   05   05
067   77   GE
068   00   00
069   97   97
070   43  RCL
071   06   06
072   65   X
073   43  RCL
074   02   02
075   65   X
076   53   (
077   43  RCL
078   01   01
079   75   -
080   43  RCL
081   05   05
082   54   )
083   55   ÷
084   53   (
085   43  RCL
086   05   05
087   85   +
088   01   1
089   54   )
090   55   ÷
091   43  RCL
092   03   03
093   54   )
094   61  GTO
095   00   00
096   58   58
097   43  RCL
098   06   06
099   92  RTN
100   76  LBL
101   14   D
102   13   C
103   43  RCL
104   04   04
105   92  RTN
106   76  LBL
107   15   E
108   13   C
109   01   1
110   75   -
111   43  RCL
112   04   04
113   54   )
114   92  RTN
115   43  RCL
116   01   01
117   85   +
118   01   1
119   54   )
120   61  GTO
121   13   C
122   76  LBL
123   18  C'
124   47  CMS
125   42  STO
126   00   00
127   42  STO
128   01   01
```

PROGRAM 6 Continued

```
129  09   9
130  69  OP
131  17  17
132  01   1
133  00   0
134  42  STO
135  02  02
136  05   5
137  00   0
138  42  STO
139  03  03
140  01   1
141  44  SUM
142  06  06
143  91  R/S
144  72  ST*
145  02  02
146  44  SUM
147  04  04
148  32  X:T
149  72  ST*
150  03  03
151  44  SUM
152  05  05
153  01   1
154  44  SUM
155  02  02
156  44  SUM
157  03  03
158  44  SUM
159  08  08
160  43  RCL
161  05  05
162  32  X:T
163  43  RCL
164  04  04
165  61  GTO
166  01  01
167  43  43
168  76  LBL
169  19  D'
170  29  CP
171  43  RCL
172  08  08
173  94  +/-
174  44  SUM
175  02  02
176  44  SUM
177  03  03
178  73  RC*
179  02  02
180  45  YX
181  73  RC*
182  03  03
183  54   )
184  49  PRD
185  06  06
186  73  RC*
187  03  03
188  42  STO
189  07  07
190  10  E'
191  35  1/X
192  49  PRD
193  06  06
194  43  RCL
195  01  01
196  49  PRD
197  06  06
198  01   1
199  44  SUM
200  02  02
201  44  SUM
202  03  03
203  94  +/-
204  44  SUM
205  01  01
206  44  SUM
207  08  08
208  43  RCL
209  08  08
210  67  EQ
211  02  02
212  16  16
213  61  GTO
214  01  01
215  78  78
216  43  RCL
217  01  01
218  42  STO
219  07  07
220  10  E'
221  65   X
222  43  RCL
223  06  06
224  54   )
225  92  RTN
226  76  LBL
227  10  E'
228  43  RCL
229  07  07
230  65   X
231  97  DSZ
232  07  07
233  10  E'
234  01   1
235  54   )
236  92  RTN
```

END PROGRAM 6

PROGRAM 7 CHI-SQUARE DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

```
001  14  D
072  11  A
100  12  B
148  13  C
179  18  C'
234  15  E
253  10  E'
355  19  D'
374  16  A'
388  17  B'
```

PROGRAM LISTING

```
000  76  LBL
001  14  D
002  43  RCL
003  15  15
004  55  ÷
005  02  2
006  85  +
007  42  STO
008  20  20
009  42  STO
010  17  17
011  93  .
012  05  5
013  54  )
014  42  STO
015  21  21
016  29  CP
017  22  INV
018  59  INT
019  67  EQ
020  00  00
021  35  35
022  89  π
023  34  ΓX
024  55  ÷
025  02  2
026  54  )
027  42  STO
028  18  18
029  01  1
030  42  STO
031  19  19
032  61  GTO
033  00  00
034  42  42
035  89  π
036  34  ΓX
037  42  STO
038  19  19
039  01  1
040  42  STO
041  18  18
042  43  RCL
043  20  20
044  32  X:T
045  01  1
046  77  GE
047  00  00
048  66  66
049  01  1
050  94  +/-
051  44  SUM
052  20  20
053  44  SUM
054  21  21
055  43  RCL
056  20  20
057  49  PRD
058  19  19
059  43  RCL
060  21  21
061  49  PRD
062  18  18
063  61  GTO
064  00  00
065  42  42
066  43  RCL
067  19  19
068  49  PRD
069  17  17
070  92  RTN
071  76  LBL
072  11  A
073  42  STO
074  01  01
075  14  D
076  43  RCL
077  01  01
078  55  ÷
079  02  2
080  54  )
081  45  YX
082  43  RCL
083  15  15
084  55  ÷
085  43  RCL
086  01  01
087  22  INV
088  23  LNX
089  54  )
090  34  ΓX
091  55  ÷
092  43  RCL
093  01  01
094  55  ÷
095  43  RCL
096  19  19
097  54  )
098  92  RTN
099  76  LBL
100  12  B
101  11  A
102  65  ×
103  02  2
104  55  ÷
105  43  RCL
106  15  15
107  42  STO
108  20  20
109  65  ×
110  43  RCL
111  01  01
112  54  )
113  42  STO
114  23  23
115  01  1
116  42  STO
117  21  21
118  42  STO
119  22  22
120  32  X:T
121  43  RCL
122  01  01
123  55  ÷
124  02  2
125  44  SUM
126  20  20
```

PROGRAM 7 Continued

127	43	RCL
128	20	20
129	54	)
130	49	PRD
131	21	21
132	43	RCL
133	21	21
134	44	SUM
135	22	22
136	43	RCL
137	22	22
138	22	INV
139	67	EQ
140	01	01
141	20	20
142	65	×
143	43	RCL
144	23	23
145	54	)
146	92	RTN
147	76	LBL
148	13	C
149	42	STD
150	09	09
151	43	RCL
152	15	15
153	32	X:T
154	01	1
155	67	EQ
156	16	A'
157	02	2
158	67	EQ
159	17	B'
160	03	3
161	00	0
162	22	INV
163	77	GE
164	01	01
165	78	78
166	18	C'
167	12	B
168	94	+/-
169	85	+
170	43	RCL
171	09	09
172	85	+
173	43	RCL
174	09	09
175	54	)
176	42	STD
177	09	09
178	76	LBL
179	18	C'
180	43	RCL
181	09	09
182	15	E
183	43	RCL
184	15	15
185	65	×
186	09	9
187	54	)
188	35	1/X
189	65	×
190	02	2
191	54	)
192	42	STD
193	14	14
194	34	√X
195	65	×
196	43	RCL
197	11	11
198	54	)
199	42	STD
200	13	13
201	94	+/-
202	85	+
203	01	1
204	75	-
205	43	RCL
206	14	14
207	54	)
208	45	Y^X
209	03	3
210	65	×
211	43	RCL
212	15	15
213	54	)
214	42	STD
215	11	11
216	43	RCL
217	13	13
218	85	+
219	01	1
220	75	-
221	43	RCL
222	14	14
223	54	)
224	45	Y^X
225	03	3
226	65	×
227	43	RCL
228	15	15
229	54	)
230	42	STD
231	13	13
232	92	RTN
233	76	LBL
234	15	E
235	42	STD
236	09	09
237	32	X:T
238	93	.
239	05	5
240	22	INV
241	77	GE
242	10	E'
243	32	X:T
244	94	+/-
245	85	+
246	01	1
247	54	)
248	42	STD
249	09	09
250	86	STF
251	01	01
252	76	LBL
253	10	E'
254	43	RCL
255	09	09
256	94	+/-
257	85	+
258	01	1
259	54	)
260	33	X^2
261	23	LNX
262	94	+/-
263	34	√X
264	42	STD
265	10	10
266	53	(
267	53	(
268	53	(
269	02	2
270	93	.

PROGRAM 7 Continued

271	05	5
272	01	1
273	05	5
274	05	5
275	01	1
276	07	7
277	85	+
278	93	.
279	08	8
280	00	0
281	02	2
282	08	8
283	05	5
284	03	3
285	65	×
286	43	RCL
287	10	10
288	85	+
289	93	.
290	00	0
291	01	1
292	00	0
293	03	3
294	02	2
295	08	8
296	65	×
297	43	RCL
298	10	10
299	33	X^2
300	54	)
301	55	÷
302	53	(
303	01	1
304	85	+
305	01	1
306	93	.
307	04	4
308	03	3
309	02	2
310	07	7
311	08	8
312	08	8
313	65	×
314	43	RCL
315	10	10
316	85	+
317	93	.
318	01	1
319	08	8
320	09	9
321	02	2
322	06	6
323	09	9
324	65	×
325	43	RCL
326	10	10
327	33	X^2
328	85	+
329	93	.
330	00	0
331	00	0
332	01	1
333	03	3
334	00	0
335	08	8
336	65	×
337	43	RCL
338	10	10
339	45	Y^X
340	03	3
341	54	)
342	54	)
343	94	+/-
344	85	+
345	43	RCL
346	10	10
347	54	)
348	42	STO
349	11	11
350	87	IFF
351	01	01
352	19	D'
353	92	RTN
354	76	LBL
355	19	D'
356	43	RCL
357	09	09
358	94	+/-
359	85	+
360	01	1
361	54	)
362	42	STO
363	09	09
364	22	INV
365	86	STF
366	01	01
367	43	RCL
368	11	11
369	94	+/-
370	42	STO
371	11	11
372	92	RTN
373	76	LBL
374	16	A'
375	43	RCL
376	09	09
377	94	+/-
378	85	+
379	01	1
380	54	)
381	55	÷
382	02	2
383	54	)
384	15	E
385	33	X^2
386	92	RTN
387	76	LBL
388	17	B'
389	43	RCL
390	09	09
391	94	+/-
392	85	+
393	01	1
394	54	)
395	23	LNX
396	94	+/-
397	65	×
398	02	2
399	54	)
400	92	RTN

END PROGRAM 7

PROGRAM 8 STUDENT'S t DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

001	14	D
072	11	A
109	12	B
275	15	E
369	13	C
395	17	B'
407	18	C'
454	10	E'

PROGRAM LISTING

000	76	LBL
001	14	D
002	43	RCL
003	15	15
004	55	÷
005	02	2
006	85	+
007	42	STO
008	20	20
009	42	STO
010	17	17
011	93	.
012	05	5
013	54	)
014	42	STO
015	21	21
016	29	CP
017	22	INV
018	59	INT
019	67	EQ
020	00	00
021	35	35
022	89	π
023	34	√X
024	55	÷
025	02	2
026	54	)
027	42	STO
028	18	18
029	01	1
030	42	STO
031	19	19
032	61	GTO
033	00	00
034	42	42
035	89	π
036	34	√X
037	42	STO
038	19	19
039	01	1
040	42	STO
041	18	18
042	43	RCL
043	20	20
044	32	X:T
045	01	1
046	77	GE
047	00	00
048	66	66
049	01	1
050	94	+/-
051	44	SUM
052	20	20
053	44	SUM
054	21	21
055	43	RCL
056	20	20
057	49	PRD
058	19	19
059	43	RCL
060	21	21
061	49	PRD
062	18	18
063	61	GTO
064	00	00
065	42	42
066	43	RCL
067	19	19
068	49	PRD
069	17	17
070	92	RTN
071	76	LBL
072	11	A
073	42	STO
074	01	01
075	14	D
076	43	RCL
077	01	01
078	33	X^2
079	55	÷
080	43	RCL
081	15	15
082	85	+
083	01	1
084	54	)
085	45	Y^X
086	53	(
087	43	RCL
088	15	15
089	85	+
090	01	1
091	54	)
092	65	×
093	43	RCL
094	15	15
095	65	×
096	89	π
097	54	)
098	34	√X
099	65	×
100	43	RCL
101	19	19
102	55	÷
103	43	RCL
104	18	18
105	54	)
106	35	1/X
107	92	RTN
108	76	LBL
109	12	B
110	42	STO
111	01	01
112	14	D
113	43	RCL
114	01	01
115	55	÷
116	43	RCL
117	15	15
118	34	√X
119	54	)
120	70	RAD
121	22	INV
122	30	TAN
123	42	STO
124	16	16
125	39	COS
126	42	STO
127	20	20
128	42	STO

PROGRAM 8 Continued

```
129   23   23
130   33   X²
131   42   STO
132   21   21
133   43   RCL
134   15   15
135   55   ÷
136   02   2
137   54   )
138   22   INV
139   59   INT
140   29   CP
141   67   EQ
142   02   02
143   16   16
144   01   1
145   32   X:T
146   43   RCL
147   15   15
148   67   EQ
149   02   02
150   11   11
151   43   RCL
152   15   15
153   75   -
154   02   2
155   54   )
156   32   X:T
157   42   STO
158   22   22
159   42   STO
160   24   24
161   67   EQ
162   01   01
163   95   95
164   43   RCL
165   21   21
166   65   ×
167   01   1
168   44   SUM
169   22   22
170   43   RCL
171   22   22
172   55   ÷
173   01   1
174   44   SUM
175   22   22
176   43   RCL
177   22   22
178   54   )
179   49   PRD
180   24   24
181   43   RCL
182   24   24
183   65   ×
184   43   RCL
185   20   20
186   54   )
187   44   SUM
188   23   23
189   43   RCL
190   22   22
191   22   INV
192   67   EQ
193   01   01
194   64   64
195   43   RCL
196   16   16
197   85   +
198   38   SIN
199   65   ×
200   43   RCL
201   23   23
202   54   )
203   65   ×
204   02   2
205   55   ÷
206   89   π
207   54   )
208   61   GTO
209   02   02
210   67   67
211   43   RCL
212   16   16
213   61   GTO
214   02   02
215   03   03
216   43   RCL
217   15   15
218   75   -
219   02   2
220   54   )
221   32   X:T
222   01   1
223   42   STO
224   20   20
225   42   STO
226   22   22
227   00   0
228   42   STO
229   23   23
230   43   RCL
231   23   23
232   67   EQ
233   02   02
234   60   60
235   53   (
236   43   RCL
237   21   21
238   65   ×
239   01   1
240   44   SUM
241   23   23
242   43   RCL
243   23   23
244   55   ÷
245   01   1
246   44   SUM
247   23   23
248   43   RCL
249   23   23
250   54   )
251   49   PRD
252   22   22
253   43   RCL
254   22   22
255   44   SUM
256   20   20
257   61   GTO
258   02   02
259   30   30
260   43   RCL
261   20   20
262   65   ×
263   43   RCL
264   16   16
265   38   SIN
266   54   )
267   55   ÷
268   02   2
269   85   +
270   93   .
271   05   5
272   54   )
```

PROGRAM 8 Continued

273	92	RTN
274	76	LBL
275	15	E
276	94	+/-
277	85	+
278	01	1
279	54	)
280	33	X^2
281	23	LNX
282	94	+/-
283	34	ΓX
284	42	STO
285	10	10
286	02	2
287	93	.
288	05	5
289	01	1
290	05	5
291	05	5
292	01	1
293	07	7
294	85	+
295	93	.
296	08	8
297	00	0
298	02	2
299	08	8
300	05	5
301	03	3
302	65	×
303	43	RCL
304	10	10
305	85	+
306	93	.
307	00	0
308	01	1
309	00	0
310	03	3
311	02	2
312	08	8
313	65	×
314	43	RCL
315	10	10
316	33	X^2
317	54	)
318	55	÷
319	53	(
320	01	1
321	85	+
322	01	1
323	93	.
324	04	4
325	03	3
326	02	2
327	07	7
328	08	8
329	08	8
330	65	×
331	43	RCL
332	10	10
333	85	+
334	93	.
335	01	1
336	08	8
337	09	9
338	02	2
339	06	6
340	09	9
341	65	×
342	43	RCL
343	10	10
344	33	X^2
345	85	+
346	93	.
347	00	0
348	00	0
349	01	1
350	03	3
351	00	0
352	08	8
353	65	×
354	43	RCL
355	10	10
356	45	Y^X
357	03	3
358	54	)
359	54	)
360	94	+/-
361	85	+
362	43	RCL
363	10	10
364	54	)
365	42	STO
366	09	09
367	92	RTN
368	76	LBL
369	13	C
370	42	STO
371	00	00
372	43	RCL
373	15	15
374	32	X:T
375	01	1
376	67	EQ
377	10	E'
378	93	.
379	05	5
380	32	X:T
381	43	RCL
382	00	00
383	77	GE
384	17	B'
385	94	+/-
386	85	+
387	01	1
388	54	)
389	42	STO
390	00	00
391	17	B'
392	94	+/-
393	92	RTN
394	76	LBL
395	17	B'
396	18	C'
397	12	B
398	94	+/-
399	48	EXC
400	00	00
401	65	×
402	02	2
403	54	)
404	44	SUM
405	00	00
406	76	LBL
407	18	C'
408	01	1
409	94	+/-
410	85	+
411	53	(
412	01	1
413	85	+
414	01	1
415	00	0
416	55	÷

PROGRAM 8 Continued

```
417  53  (
418  03  3
419  65  ×
420  53  (
421  43  RCL
422  15  15
423  75  -
424  01  1
425  93  .
426  05  5
427  07  7
428  54  )
429  54  )
430  54  )
431  34  √X
432  54  )
433  55  ÷
434  05  5
435  54  )
436  42  STO
437  02  02
438  43  RCL
439  00  00
440  15  E
441  33  X²
442  65  ×
443  43  RCL
444  02  02
445  85  +
446  01  1
447  54  )
448  65  ×
449  43  RCL
450  09  09
451  54  )
452  92  RTN
453  76  LBL
454  10  E'
455  93  .
456  05  5
457  32  X:T
458  43  RCL
459  00  00
460  22  INV
461  67  EQ
462  04  04
463  70  70
464  94  +/-
465  85  +
466  01  1
467  54  )
468  42  STO
469  00  00
470  65  ×
471  89  π
472  54  )
473  70  RAD
474  30  TAN
475  35  1/X
476  94  +/-
477  92  RTN
```

END PROGRAM 8

PROGRAM 9 F DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

```
001   12   B
375   11   A
386   15   E
404   19  D'
498   13   C
526   10  E'
607   16  A'
617   17  B'
632   14   D
650   18  C'
```

PROGRAM LISTING

```
000  76  LBL
001  12    B
002  42  STO
003  17   17
004  22  INV
005  86  STF
006  01   01
007  43  RCL
008  15   15
009  55    ÷
010  02    2
011  54    )
012  22  INV
013  59  INT
014  29   CP
015  67   EQ
016  00   00
017  20   20
018  86  STF
019  01   01
020  22  INV
021  86  STF
022  02   02
023  43  RCL
024  16   16
025  55    ÷
026  02    2
027  54    )
028  22  INV
029  59  INT
030  67   EQ
031  00   00
032  35   35
033  86  STF
034  02   02
035  43  RCL
036  17   17
037  87  IFF
038  01   01
039  01   01
040  43   43
041  87  IFF
042  02   02
043  00   00
044  53   53
045  43  RCL
046  16   16
047  32  X:T
048  43  RCL
049  15   15
050  77   GE
051  01   01
052  47   47
053  43  RCL
054  15   15
055  42  STO
056  18   18
057  43  RCL
058  16   16
059  42  STO
060  19   19
061  42  STO
062  25   25
063  71  SBR
064  01   01
065  30   30
066  42  STO
067  20   20
068  94  +/-
069  42  STO
070  21   21
071  43  RCL
072  18   18
073  55    ÷
074  02    2
075  54    )
076  32  X:T
077  01    1
078  44  SUM
079  21   21
080  42  STO
081  22   22
082  42  STO
083  23   23
084  42  STO
085  24   24
086  43  RCL
087  22   22
088  77   GE
089  01   01
090  15   15
091  35  1/X
092  65    ×
093  43  RCL
094  21   21
095  65    ×
096  43  RCL
097  19   19
098  55    ÷
099  02    2
100  44  SUM
101  19   19
102  54    )
103  49  PRD
104  23   23
105  01    1
106  44  SUM
107  22   22
108  43  RCL
109  23   23
110  44  SUM
111  24   24
112  61  GTO
113  00   00
114  86   86
115  43  RCL
116  20   20
117  34   √X
118  45   Y^X
119  43  RCL
120  25   25
121  65    ×
122  43  RCL
123  24   24
124  54    )
125  94  +/-
126  85    +
```

PROGRAM 9 Continued

127	01	1
128	54	)
129	92	RTN
130	43	RCL
131	15	15
132	55	÷
133	43	RCL
134	16	16
135	65	×
136	43	RCL
137	17	17
138	85	+
139	01	1
140	54	)
141	35	1/X
142	92	RTN
143	87	IFF
144	02	02
145	01	01
146	79	79
147	43	RCL
148	16	16
149	42	STD
150	18	18
151	43	RCL
152	15	15
153	42	STD
154	19	19
155	42	STD
156	25	25
157	71	SBR
158	01	01
159	30	30
160	42	STD
161	21	21
162	94	+/-
163	42	STD
164	20	20
165	01	1
166	44	SUM
167	20	20
168	22	INV
169	44	SUM
170	21	21
171	71	SBR
172	00	00
173	71	71
174	94	+/-
175	85	+
176	01	1
177	54	)
178	92	RTN
179	65	×
180	43	RCL
181	15	15
182	55	÷
183	43	RCL
184	16	16
185	54	)
186	34	√X
187	70	RAD
188	22	INV
189	30	TAN
190	42	STD
191	17	17
192	38	SIN
193	42	STD
194	20	20
195	43	RCL
196	17	17
197	39	COS
198	42	STD
199	21	21
200	42	STD
201	22	22
202	42	STD
203	23	23
204	01	1
205	42	STD
206	24	24
207	42	STD
208	25	25
209	32	X:T
210	43	RCL
211	16	16
212	67	EQ
213	02	02
214	58	58
215	75	-
216	02	2
217	54	)
218	32	X:T
219	43	RCL
220	25	25
221	67	EQ
222	02	02
223	50	50
224	43	RCL
225	21	21
226	33	X^2
227	65	×
228	43	RCL
229	24	24
230	65	×
231	02	2
232	44	SUM
233	25	25
234	55	÷
235	43	RCL
236	25	25
237	54	)
238	49	PRD
239	23	23
240	43	RCL
241	23	23
242	44	SUM
243	22	22
244	01	1
245	44	SUM
246	24	24
247	61	GTD
248	02	02
249	19	19
250	43	RCL
251	20	20
252	49	PRD
253	22	22
254	43	RCL
255	22	22
256	44	SUM
257	17	17
258	01	1
259	42	STD
260	22	22
261	01	1
262	42	STD
263	24	24
264	32	X:T
265	43	RCL
266	15	15
267	67	EQ
268	03	03
269	60	60
270	43	RCL

PROGRAM 9 Continued

271	16	16
272	67	EQ
273	02	02
274	98	98
275	42	STO
276	23	23
277	01	1
278	22	INV
279	44	SUM
280	23	23
281	43	RCL
282	23	23
283	49	PRD
284	24	24
285	01	1
286	22	INV
287	44	SUM
288	23	23
289	43	RCL
290	23	23
291	22	INV
292	49	PRD
293	24	24
294	22	INV
295	67	EQ
296	02	02
297	77	77
298	43	RCL
299	21	21
300	45	YX
301	43	RCL
302	16	16
303	65	×
304	43	RCL
305	20	20
306	54	)
307	49	PRD
308	24	24
309	43	RCL
310	15	15
311	32	X:T
312	43	RCL
313	16	16
314	75	-
315	01	1
316	42	STO
317	26	26
318	42	STO
319	27	27
320	54	)
321	42	STO
322	25	25
323	02	2
324	44	SUM
325	25	25
326	44	SUM
327	26	26
328	43	RCL
329	26	26
330	77	GE
331	03	03
332	51	51
333	35	1/X
334	65	×
335	43	RCL
336	25	25
337	65	×
338	43	RCL
339	20	20
340	33	X²
341	54	)
342	49	PRD
343	27	27
344	43	RCL
345	27	27
346	44	SUM
347	22	22
348	61	GTO
349	03	03
350	23	23
351	43	RCL
352	22	22
353	65	×
354	43	RCL
355	24	24
356	54	)
357	22	INV
358	44	SUM
359	17	17
360	01	1
361	75	-
362	43	RCL
363	17	17
364	65	×
365	02	2
366	55	÷
367	89	π
368	54	)
369	94	+/-
370	85	+
371	01	1
372	54	)
373	92	RTN
374	76	LBL
375	11	A
376	42	STO
377	16	16
378	32	X:T
379	42	STO
380	15	15
381	03	3
382	69	OP
383	17	17
384	92	RTN
385	76	LBL
386	15	E
387	42	STO
388	08	08
389	93	.
390	05	5
391	32	X:T
392	43	RCL
393	08	08
394	77	GE
395	19	D'
396	71	SBR
397	04	04
398	09	09
399	94	+/-
400	42	STO
401	11	11
402	92	RTN
403	76	LBL
404	19	D'
405	94	+/-
406	85	+
407	01	1
408	54	)
409	33	X²
410	23	LNX
411	94	+/-
412	34	ΓX
413	42	STO
414	29	29

PROGRAM 9 Continued

415	02	2
416	93	.
417	05	5
418	01	1
419	05	5
420	05	5
421	01	1
422	07	7
423	85	+
424	93	.
425	08	8
426	00	0
427	02	2
428	08	8
429	05	5
430	03	3
431	65	×
432	43	RCL
433	29	29
434	85	+
435	93	.
436	00	0
437	01	1
438	00	0
439	03	3
440	02	2
441	08	8
442	65	×
443	43	RCL
444	29	29
445	33	X^2
446	54	)
447	55	÷
448	53	(
449	01	1
450	85	+
451	01	1
452	93	.
453	04	4
454	03	3
455	02	2
456	07	7
457	08	8
458	08	8
459	65	×
460	43	RCL
461	29	29
462	85	+
463	93	.
464	01	1
465	08	8
466	09	9
467	02	2
468	06	6
469	09	9
470	65	×
471	43	RCL
472	29	29
473	33	X^2
474	85	+
475	93	.
476	00	0
477	00	0
478	01	1
479	03	3
480	00	0
481	08	8
482	65	×
483	43	RCL
484	29	29
485	45	Y^X
486	03	3
487	54	)
488	54	)
489	94	+/-
490	85	+
491	43	RCL
492	29	29
493	54	)
494	42	STO
495	11	11
496	92	RTN
497	76	LBL
498	13	C
499	42	STO
500	09	09
501	01	1
502	32	X:T
503	43	RCL
504	15	15
505	67	EQ
506	16	A'
507	43	RCL
508	16	16
509	67	EQ
510	17	B'
511	43	RCL
512	09	09
513	10	E'
514	12	B
515	94	+/-
516	85	+
517	43	RCL
518	09	09
519	85	+
520	43	RCL
521	09	09
522	54	)
523	10	E'
524	92	RTN
525	76	LBL
526	10	E'
527	15	E
528	33	X^2
529	75	-
530	03	3
531	54	)
532	55	÷
533	06	6
534	54	)
535	42	STO
536	17	17
537	43	RCL
538	15	15
539	75	-
540	01	1
541	54	)
542	35	1/X
543	42	STO
544	18	18
545	85	+
546	53	(
547	43	RCL
548	16	16
549	75	-
550	01	1
551	54	)
552	35	1/X
553	22	INV
554	44	SUM
555	18	18
556	54	)
557	35	1/X
558	65	×

PROGRAM 9 Continued

559	02	2
560	54	)
561	42	STO
562	19	19
563	85	+
564	43	RCL
565	17	17
566	54	)
567	34	ΓX
568	65	×
569	43	RCL
570	11	11
571	55	÷
572	43	RCL
573	19	19
574	54	)
575	85	+
576	53	(
577	43	RCL
578	18	18
579	65	×
580	53	(
581	43	RCL
582	17	17
583	85	+
584	05	5
585	55	÷
586	06	6
587	75	-
588	02	2
589	55	÷
590	53	(
591	03	3
592	65	×
593	43	RCL
594	19	19
595	54	)
596	54	)
597	54	)
598	94	+/-
599	54	)
600	65	×
601	02	2
602	54	)
603	22	INV
604	23	LNX
605	92	RTN
606	76	LBL
607	16	A'
608	43	RCL
609	16	16
610	42	STO
611	15	15
612	67	EQ
613	14	D
614	18	C'
615	92	RTN
616	76	LBL
617	17	B'
618	43	RCL
619	09	09
620	94	+/-
621	85	+
622	01	1
623	54	)
624	42	STO
625	09	09
626	43	RCL
627	15	15
628	18	C'
629	35	1/X
630	92	RTN
631	76	LBL
632	14	D
633	43	RCL
634	09	09
635	94	+/-
636	85	+
637	01	1
638	54	)
639	65	×
640	89	π
641	55	÷
642	02	2
643	54	)
644	70	RAD
645	30	TAN
646	35	1/X
647	33	X²
648	92	RTN
649	76	LBL
650	18	C'
651	43	RCL
652	09	09
653	85	+
654	01	1
655	54	)
656	55	÷
657	02	2
658	54	)
659	42	STO
660	00	00
661	53	(
662	01	1
663	94	+/-
664	85	+
665	53	(
666	01	1
667	85	+
668	01	1
669	00	0
670	55	÷
671	53	(
672	03	3
673	65	×
674	53	(
675	43	RCL
676	15	15
677	75	-
678	01	1
679	93	.
680	05	5
681	07	7
682	54	)
683	54	)
684	54	)
685	34	ΓX
686	54	)
687	55	÷
688	05	5
689	54	)
690	42	STO
691	02	02
692	43	RCL
693	00	00
694	15	E
695	33	X²
696	65	×
697	43	RCL
698	02	02
699	85	+
700	01	1
701	54	)
702	65	×

PROGRAM 9 Continued

```
703  43 RCL
704  11   11
705  54  )
706  33 X²
707  92 RTN
```

END PROGRAM 9

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