SAMPLING

The subroutines in this chapter are intended for use in developing application programs in the general areas of

1. Acceptance Sampling
2. Preference Testing
3. Survey Sampling

The current chapter contents are all in the survey sampling category.

Quick Reference Guide to Chapter Abilities

A synopsis of the purpose of each of the subroutines follows:

- SSPAND - simple random sampling with proportion data with inferences regarding the population proportion and total.
- SSPBLK - stratified random sampling with proportion data with inferences regarding the population proportion and total.
- SSRAND - simple random sampling with continuous data with inferences regarding the population mean and total using ratio or regression estimation.
- SSRBLK - stratified random sampling with continuous data with inferences regarding the population mean and total using ratio or regression estimation.
- SSSAND - simple random sampling with continuous data with inferences regarding the population mean and total.
- SSSBLK - stratified random sampling with continuous data with inferences regarding the population mean and total.
- SSSCAN - single stage cluster sampling with continuous data with inferences regarding the population mean and total.
- SSSEST - two stage sampling with continuous data and equisized primary units with inferences regarding the population mean and total.

Featured Abilities

For the six continuous data subroutines, the amount of input data can be quite large for some applications. The computations do not require that all data points be in core at one time. Actually, only a single data point is required to be in core at one time to successfully complete the computations. Thus, these routines allow the user to input only a subvector of an entire vector of data (or submatrix of the entire matrix of data) for a single call. Several calls are then required. The size of the subvector (or submatrix) is under user control. Where core availability is no problem, the user can enter his entire data set and call the routine only once.

Name Conventions for This Chapter

All routines in this chapter begin with the letter S. The second letter specifies the general sampling area for the routine, with A, P, and S for acceptance sampling, preference testing, and survey sampling, respectively. In the survey sampling area letters 3 and 4 have the following convention, with letters 5 and 6 being optional.

Letter 3 - Data type and estimation technique
P for proportion data
R for continuous data with ratio or regression estimation
S for continuous data with standard estimation

Letter 4 - Survey design type
A for simple random sample
B for stratified random sample
:
:

When possible, letters 5 and 6 are chosen to make the name as mnemonically meaningful as possible.

IMSL ROUTINE NAME - SSPAND

PURPOSE - SIMPLE RANDOM SAMPLING WITH PROPORTION DATA-INFERENCES REGARDING THE POPULATION PROPORTION AND TOTAL

USAGE - CALL SSPAND (IOPT,NBR,ALPHA,STAT,IDIST,IER)

ARGUMENTS

IOPT - INPUT SUBPOPULATION AND NUMBER OF CLASSES INDICATOR. THE USUAL SITUATION FOR WHICH THIS PROGRAM IS APPLICABLE IS ONE WHERE A POPULATION IS SAMPLED AND EACH SAMPLE UNIT IS CATEGORIZED INTO ONE OF TWO CLASSES. EXTENSIONS TO MORE THAN TWO CLASSES WHERE SOME CLASSES ARE OR ARE NOT OMITTED, TO SUBPOPULATIONS, AND TO ANY COMBINATION OF THE PRECEDING IS ALLOWED.
  IF IOPT = 0, THE SAMPLE IS FROM A POPULATION WHERE THERE ARE TWO OR MORE CLASSES, BUT NO CLASSES ARE OMITTED.
  IF IOPT IS NEGATIVE, THE SAMPLE IS FROM A POPULATION WHERE THERE ARE THREE OR MORE CLASSES AND AT LEAST ONE CLASS IS OMITTED, OR THE SAMPLE IS FROM A SUBPOPULATION WHERE THERE ARE TWO OR MORE CLASSES AND CLASSES MAY OR MAY NOT BE OMITTED. THE NUMBER OF UNITS, NBR(4), IN THE POPULATION (OR SUBPOPULATION) CORRESPONDING TO THE INCLUDED CLASSES IS UNKNOWN.
  IF IOPT IS POSITIVE, THE SITUATION IS AS FOR IOPT NEGATIVE, EXCEPT THAT NBR(4) IS KNOWN.

NBR - INPUT VECTOR OF LENGTH 5. NBR(I) CONTAINS, WHEN
  I=1, NUMBER OF SAMPLE UNITS IN THE CLASS OF INTEREST, FOR THE POPULATION (OR SUBPOPULATION) OF INTEREST.
  I=2, NUMBER OF SAMPLE UNITS IN THE INCLUDED CLASSES, FOR THE POPULATION (OR SUBPOPULATION) OF INTEREST.
  I=3, NUMBER OF SAMPLE UNITS IN THE ENTIRE RANDOM SAMPLE. REQUIRED ONLY WHEN IOPT IS NEGATIVE.
  I=4, NUMBER OF UNITS IN THE POPULATION (OR SUBPOPULATION) CORRESPONDING TO THE INCLUDED CLASSES. NOT REQUIRED WHEN IOPT IS NEGATIVE.
  I=5, NUMBER OF UNITS IN THE POPULATION. REQUIRED ONLY WHEN IOPT IS NEGATIVE.

ALPHA - INPUT VALUE IN THE EXCLUSIVE INTERVAL (0,1) USED FOR COMPUTING 100(1-ALPHA) PERCENT CONFIDENCE INTERVALS FOR THE PROPORTION AND TOTAL PARAMETERS FOR THE CLASS AND POPULATION (OR SUBPOPULATION) OF INTEREST.

STAT - OUTPUT VECTOR OF LENGTH 9. STAT(I) CONTAINS, WHEN
I=1, ESTIMATE OF THE PROPORTION.
I=2, ESTIMATE OF THE TOTAL.
I=3, VARIANCE ESTIMATE OF THE PROPORTION ESTIMATE.
I=4, VARIANCE ESTIMATE OF THE TOTAL ESTIMATE.
I=5, LOWER CONFIDENCE LIMIT FOR THE PROPORTION.
I=6, UPPER CONFIDENCE LIMIT FOR THE PROPORTION.
I=7, LOWER CONFIDENCE LIMIT FOR THE TOTAL.
I=8, UPPER CONFIDENCE LIMIT FOR THE TOTAL.
I=9,ESTIMATE (EXPRESSED AS A PERCENTAGE) OF THE COEFFICIENT OF VARIATION OF THE TOTAL ESTIMATE. NOT RETURNED IF NBR(1)=0.

IDIST - OUTPUT INDICATOR OF THE DISTRIBUTION USED TO APPROXIMATE THE HYPERGEOMETRIC DISTRIBUTION FOR THE CONFIDENCE INTERVAL CALCULATIONS.
IF IDIST = 0, THE NORMAL IS USED.
IF IDIST IS NEGATIVE, THE POISSON IS USED.
IF IDIST IS POSITIVE, THE BINOMIAL IS USED.

IER - ERROR PARAMETER. (OUTPUT)
TERMINAL ERROR
IER = 129 INDICATES NBR(1) IS LESS THAN 0, OR THAT NBR(2) IS LESS THAN 2, OR THAT NBR(1) EXCEEDS NBR(2).
IER = 130 INDICATES, WHEN IOPT IS NEGATIVE, THAT NBR(3) IS LESS THAN NBR(2), OR THAT NBR(5) IS LESS THAN NBR(3).
IER = 131 INDICATES, WHEN IOPT IS NON-NEGATIVE, THAT NBR(2) EXCEEDS NBR(4).
IER = 132 INDICATES THAT ALPHA IS NOT IN THE EXCLUSIVE INTERVAL (0,1), OR THAT AN ERROR OCCURRED IN IMSL ROUTINE BELBIN OR BELPOS.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - H32/BELBIN,BELPOS,MDBETA,MDBETI,MDCH,MDCHI, MDNOR,MDNRIS,MERFI,MERRC=ERFC,MGAMAD=DGAMMA, MLGAMD=DLGAMA,UERTST,UGETIO
- H36,H48,H60/BELBIN,BELPOS,MDBETA,MDBETI, MDCH,MDCHI,MDNOR,MDNRIS,MERFI,MERRC=ERFC, MGAMA=GAMMA,MLGAMA=ALGAMA,UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

Algorithm

This subroutine computes point and interval estimates of the population proportion and total using the results of a simple random sample The usual situation is one where each unit in the population may be

categorized into one of two classes. Extensions to more than two classes, omission of classes, and extensions to subpopulations are allowed.

The computations are described in Chapter 3 of the reference below. For the interval estimation calculations, depending on the input data, the binomial, Poisson, or normal distribution is used to approximate the hypergeometric distribution.

See reference:

Cochran, W. G., Sampling Techniques, John Wiley & Sons, New York, 1963, Chapter 3.

Programming Notes

The notation used by Cochran (1963) for selected SSPAND calling sequence parameters is given below.

SSPAND Parameter	NBR(1)	NBR(2)	NBR(3)	NBR(4)	NBR(5)
Cochran's Notation	a_1	n'	n	N'	N

Example

Suppose it is desired to compute point and interval estimates of the population proportion and total for a class of interest in a population of 100 units. Assuming a sample of size 32 contained 16 units in the class of interest, SSPAND may be used as follows:

Input:

```
INTEGER  IOPT,NBR(5),IDIST,IER
REAL     ALPHA,STAT(9)
IOPT = 0
NBR  = (16,32,-,100,-)
ALPHA=  0.10
CALL SSPAND (IOPT,NBR,ALPHA,STAT,IDIST,IER)
   :
   :
END
```

Output:

```
STAT = (0.50000,50.000,0.0054839,54.839,0.36257,0.63743,37.804,
        62.196,14.811)
IDIST= 0
IER  = 0
```

IMSL ROUTINE NAME - SSPBLK

PURPOSE - STRATIFIED RANDOM SAMPLING WITH PROPORTION DATA - INFERENCES REGARDING THE POPULATION PROPORTION AND TOTAL

USAGE - CALL SSPBLK (NBR,NH,IN,ALPHA,PH,STAT,IER)

ARGUMENTS

NBR - INPUT NUMBER OF STRATA INTO WHICH THE SAMPLE IS DIVIDED.

NH - INPUT NBR BY 3 MATRIX CONTAINING THE OBSERVED NUMBER OF UNITS IN EACH STRATUM FOR THE CLASS OF INTEREST AND THE SAMPLE IN COLUMNS 1 AND 2, RESPECTIVELY. THE NUMBER OF UNITS IN EACH STRATUM IN THE POPULATION ARE IN COLUMN 3. EACH ROW MUST CONTAIN THE INFORMATION FOR A SINGLE STRATUM ONLY. IN THE CASE WHERE POPULATION STRATA SIZES ARE NOT KNOWN, ESTIMATES MUST BE ENTERED IN THEIR PLACE.

IN - INPUT ROW DIMENSION OF MATRIX NH EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

ALPHA - INPUT VALUE IN THE EXCLUSIVE INTERVAL (0,1) USED FOR COMPUTING 100(1-ALPHA) PERCENT CONFIDENCE INTERVALS FOR THE PROPORTION AND TOTAL PARAMETERS.

PH - OUTPUT VECTOR OF LENGTH NBR CONTAINING THE WITHIN STRATA PROPORTION ESTIMATES.

STAT - OUTPUT VECTOR OF LENGTH 10. STAT(I) CONTAINS, WHEN
- I=1, ESTIMATE OF THE PROPORTION.
- I=2, ESTIMATE OF THE TOTAL.
- I=3, VARIANCE ESTIMATE OF THE PROPORTION ESTIMATE.
- I=4, VARIANCE ESTIMATE OF THE TOTAL ESTIMATE.
- I=5, LOWER CONFIDENCE LIMIT FOR THE PROPORTION.
- I=6, UPPER CONFIDENCE LIMIT FOR THE PROPORTION.
- I=7, LOWER CONFIDENCE LIMIT FOR THE TOTAL.
- I=8, UPPER CONFIDENCE LIMIT FOR THE TOTAL.
- I=9, ESTIMATE (EXPRESSED AS A PERCENTAGE) OF THE COEFFICIENT OF VARIATION OF THE TOTAL ESTIMATE.
- I=10, VARIANCE ESTIMATE OF THE MEAN ESTIMATE ASSUMING THAT SAMPLING WAS SIMPLE RANDOM INSTEAD OF STRATIFIED RANDOM.

IER - ERROR PARAMETER. (OUTPUT)
TERMINAL ERROR
- IER = 129 INDICATES NBR IS LESS THAN 2.
- IER = 130 INDICATES AT LEAST ONE ROW OF NH IS SPECIFIED INCORRECTLY. THIS ERROR OCCURS, IF IN ANY ROW, THE FIRST ELEMENT EXCEEDS THE SECOND ELEMENT, OR THE SECOND

ELEMENT EXCEEDS THE THIRD ELEMENT, OR THE SECOND ELEMENT IS LESS THAN 2.
IER = 131 INDICATES THAT ALPHA IS NOT IN THE EXCLUSIVE INTERVAL (0,1).

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - MDNRIS,MERFI,UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

Algorithm

Subroutine SSPBLK computes point and interval estimates of the population proportion and total using a stratified random sample.

The proportion and total estimates are assumed to be approximately normally distributed for the interval estimate calculations. The computations are described in Chapter 5 of the following reference.

See reference:

Cochran, W. G., Sampling Techniques, John Wiley and Sons, New York, 1963, Chapter 5.

Programming Notes

The notation used by Cochran (1963) for selected SSPBLK calling sequence parameters is given below.

SSPBLK Parameter	NBR	NH(h,1)	NH(h,2)	NH(h,3)	PH(h)
Cochran's Notation	L	a_h	n_h	N_h	p_h

Example

Suppose it is desired to compute point and interval estimates of the population proportion and total for a population of 300 units divided into three strata. Given a stratified sample of 150 units, SSPBLK may be used as follows:

Input:

```
INTEGER  NBR,NH(3,3),IN,IER
REAL     ALPHA,PH(3),STAT(10)
NBR  =     3
```

$$NH = \begin{bmatrix} 33 & 40 & 80 \\ 18 & 50 & 100 \\ 29 & 60 & 120 \end{bmatrix}$$

```
IN    =     3
ALPHA=      0.10
CALL SSPBLK (NBR,NH,IN,ALPHA,PH,STAT,IER)

Output:

PH    =     (0.82500,0.36000,0.48333)
STAT  =     (0.53333,160.00,0.00073145,65.831,0.48885,0.57782,146.65,
             173.35,5.0710,0.00011969)
IER   =     0
```

IMSL ROUTINE NAME - SSRAND

PURPOSE - SIMPLE RANDOM SAMPLING WITH CONTINUOUS DATA - INFERENCES REGARDING THE POPULATION MEAN AND TOTAL USING RATIO OR REGRESSION ESTIMATION

USAGE - CALL SSRAND (Y,IY,IOPT,NBR,ALPHA,TEMP,XBAR,B, STAT,IER)

ARGUMENTS

Y - INPUT NBR(2) BY 2 SUBMATRIX OF THE MATRIX (CALL IT YY) CONTAINING THE ENTIRE RANDOM SAMPLE. THE AUXILIARY VARIABLE SETTINGS ARE IN COLUMN ONE WITH CORRESPONDING VARIABLE OF INTEREST SETTINGS IN COLUMN TWO. THE LAST SUBMATRIX IN YY MAY HAVE FEWER THAN NBR(2) ROWS. SEE EXAMPLE.

IY - INPUT ROW DIMENSION OF MATRIX Y EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

IOPT - INPUT ESTIMATION OPTION.
IF IOPT IS NEGATIVE, ONLY INFERENCE ABOUT THE POPULATION RATIO IS DESIRED.
IF IOPT = 0, RATIO ESTIMATION IS TO BE USED FOR INFERENCE ABOUT THE POPULATION MEAN, TOTAL, AND RATIO.
IF IOPT IS POSITIVE, REGRESSION ESTIMATION IS TO BE USED FOR INFERENCE ABOUT THE POPULATION MEAN AND TOTAL.

NBR - INPUT VECTOR OF LENGTH 7. NBR(I) CONTAINS, WHEN
I=1, NUMBER OF PAIRS OF OBSERVATIONS IN YY.
I=2, NUMBER OF PAIRS OF OBSERVATIONS IN EACH SUBMATRIX Y, NOT INCLUDING THE LAST SUBMATRIX WHERE THE NUMBER MAY BE LESS THAN OR EQUAL TO NBR(2). HOWEVER NBR(2) SHOULD BE THE SAME FOR ALL CALLS.
I=3, THE NUMBER OF THE SUBMATRIX STORED IN Y. SEE REMARKS.
I=4, THE TEMPORARY MEAN INDICATOR. IF NBR(4) = 0, THE USER SUPPLIES TEMPORARY MEANS IN TEMP. OTHERWISE, THE FIRST ROW OF YY (OR FIRST ROW OF Y WHEN NBR(3) = 1) IS UTILIZED.
I=5, NUMBER OF PAIRS OF ELEMENTS IN THE SAMPLED POPULATION.
I=6, OPTION FOR POPULATION MEAN OF THE AUXILIARY VARIATE, DEFINED ONLY WHEN IOPT IS NEGATIVE. IF NBR(6) = 0, THIS MEAN IS KNOWN AND IS INPUT VIA XBAR. FOR NON-ZERO NBR(6) THE MEAN IS UNKNOWN.
I=7, OPTION FOR THE REGRESSION COEFFICIENT, DEFINED ONLY WHEN IOPT IS POSITIVE. IF NBR(7) = 0, THE REGRESSION COEFFICIENT IS PREASSIGNED VIA B. FOR NON-ZERO NBR(7) THIS PARAMETER IS ESTIMATED FROM THE DATA.

ALPHA - INPUT VALUE IN THE EXCLUSIVE INTERVAL (0,1) USED FOR COMPUTING 100(1-ALPHA) PERCENT CONFIDENCE INTERVALS FOR THE MEAN, TOTAL, AND RATIO PARAMETERS. THE VALUE 0.05 IS A COMMON CHOICE.

TEMP - INPUT VECTOR OF LENGTH 2. IF NBR(4) = 0, TEMP MUST CONTAIN TEMPORARY MEANS FOR THE TWO COLUMNS OF YY, RESPECTIVELY. OTHERWISE TEMP IS UNDEFINED.

XBAR - INPUT POPULATION MEAN OF THE AUXILIARY VARIATE. NOT REQUIRED WHEN IOPT IS NEGATIVE AND NBR(6) IS NON-ZERO.

B - INPUT PREASSIGNED REGRESSION COEFFICIENT. REQUIRED ONLY WHEN IOPT IS POSITIVE AND NBR(7) = 0.

STAT - OUTPUT VECTOR OF LENGTH 18. NOTE THAT STAT(1) THROUGH STAT(8) ARE NOT DEFINED WHEN IOPT IS NEGATIVE, AND THAT STAT(9) THROUGH STAT(12) ARE NOT DEFINED WHEN IOPT IS POSITIVE.
STAT(I) CONTAINS, FOR
I=1, ESTIMATE OF THE MEAN.
I=2, ESTIMATE OF THE TOTAL.
I=3, VARIANCE ESTIMATE OF THE MEAN ESTIMATE.
I=4, VARIANCE ESTIMATE OF THE TOTAL ESTIMATE
I=5, LOWER CONFIDENCE LIMIT FOR THE MEAN.
I=6, UPPER CONFIDENCE LIMIT FOR THE MEAN.
I=7, LOWER CONFIDENCE LIMIT FOR THE TOTAL.
I=8, UPPER CONFIDENCE LIMIT FOR THE TOTAL.
I=9, ESTIMATE OF THE RATIO.
I=10,VARIANCE ESTIMATE OF THE RATIO ESTIMATE
I=11,LOWER CONFIDENCE LIMIT FOR THE RATIO.
I=12,UPPER CONFIDENCE LIMIT FOR THE RATIO.
I=13, ESTIMATE (EXPRESSED AS A PERCENTAGE) OF THE COEFFICIENT OF VARIATION OF THE MEAN, TOTAL, AND RATIO ESTIMATES THAT ARE DEFINED, AS CONTROLLED BY IOPT.
I=14,ESTIMATE (EXPRESSED AS A PERCENTAGE) OF THE COEFFICIENT OF VARIATION OF THE MEAN OF THE AUXILIARY VARIATE (COLUMN ONE OF YY).
I=15,ESTIMATE (EXPRESSED AS A PERCENTAGE) OF THE COEFFICIENT OF VARIATION OF THE MEAN OF THE VARIABLE OF INTEREST (COLUMN TWO OF YY).
I=16,AVERAGE OF COLUMN ONE OF YY.
I=17,AVERAGE OF COLUMN TWO OF YY.
I=18,ESTIMATE OF THE REGRESSION COEFFICIENT. DEFINED ONLY WHEN IOPT IS POSITIVE AND NBR(7) IS NON-ZERO.

IER - ERROR PARAMETER. (OUTPUT)
WARNING ERROR
IER = 33 INDICATES THAT EITHER THE SAMPLE SIZE (NBR(1)) DOES NOT EXCEED 30, OR THAT ONE OR BOTH OF THE COEFFICIENTS OF VARIATION (STAT(14) AND STAT(15)) FOR THE

TWO COLUMNS OF YY EXCEED 10 PERCENT. THE RESULTS DEPEND ON THE ASSUMPTION OF APPROXIMATE NORMALITY OF THE PARAMETER ESTIMATES AND THAT ASSUMPTION MAY BE INVALID IN THIS CASE.

TERMINAL ERROR

IER = 130 INDICATES NBR(1) IS LESS THAN 3 OR THAT NBR(1) EXCEEDS NBR(5).

IER = 131 INDICATES NBR(3) IS LESS THAN ONE OR THAT NBR(2)*(NBR(3)-1) EXCEEDS NBR(1) (I.E., THE NUMBER OF THE SUBMATRIX (NBR(3)) IMPLIES THE NUMBER OF OBSERVATIONS IN YY (NBR(1)) IS NOT SUFFICIENT).

IER = 132 INDICATES THAT NBR(2) IS LESS THAN 1 OR THAT ALPHA IS NOT IN THE EXCLUSIVE INTERVAL (0,1).

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - MDNRIS,MERFI,UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS BETWEEN THE FIRST CALL AND THE LAST CALL (M-TH CALL) TO SSRAND ONLY NBR(3) MAY BE MODIFIED AND IT SHOULD FOLLOW THE PATTERN 1,2,...,M. THOUGH THIS PATTERN IS THE OBVIOUS ONE TO FOLLOW, IT IS NOT NECESSARY IN ITS ENTIRETY. FOR CALLS 2,3,...,M-1, NBR(3) MAY TAKE ANY VALUE IN THE SET (2,3,...,M-1). ON THE FIRST CALL NBR(3) MUST EQUAL 1, AND ON THE M-TH CALL NBR(3) MUST EQUAL M.

Algorithm

Let (NBR(1),NBR(2)) = (R,r). Then, given an R by 2 matrix (call it YY) containing the random sample, SSRAND computes point and interval estimates for the population mean, total, and ratio (optionally), with options on the choice of estimation technique. Only a submatrix, Y, of YY is available to the routine at any one time and the results are available only after SSRAND has been called for the m-th time, where m is the greatest integer in (R+r-1)/r, and r is the number of rows in submatrix Y. Y is comprised of a set of rows of YY, which are presented, in order, to Y through the call.

Let $(x_i^{(k)}, y_i^{(k)})$ be the i-th row of submatrix Y, where Y is the k-th submatrix in YY, for i=1,2,...,n; k=1,2,...,m; and

$$n = \begin{cases} r & , \ k=1,2,\ldots,m-1 \\ R-(m-1)r, & k=m \end{cases}$$

Let (T_x, T_y) = (TEMP(1), TEMP(2)) and let $s_i^{(k)} = x_i^{(k)} - T_x$ and $t_i^{(k)} = y_i^{(k)} - T_y$, for i and k as in the definition of $(x_i^{(k)}, y_i^{(k)})$, above. Then

$$\bar{x} = \text{STAT(16)} = \left\{ \sum_{k=1}^{m} \sum_{i=1}^{n} x_i^{(k)} \right\} \Big/ R$$

$$\bar{y} = \text{STAT(17)} = \left\{ \sum_{k=1}^{m} \sum_{i=1}^{n} y_i^{(k)} \right\} \Big/ R,$$

and

$$s_x^2 = \sum_{k=1}^{m} \sum_{i=1}^{n} \left[s_i^{(k)} \right]^2 - R\,(\bar{X} - T_x)^2$$

$$s_y^2 = \sum_{k=1}^{m} \sum_{i=1}^{n} \left[t_i^{(k)} \right]^2 - R\,(\bar{y} - T_y)^2$$

$$s_{xy} = \sum_{k=1}^{m} \sum_{i=1}^{n} (s_i^{(k)})(t_i^{(k)}) - R\,(\bar{X} - T_x)(\bar{y} - T_y).$$

The remaining computations depend on the above and are described in Chapters 6 and 7 of the reference below.

SSRAND is designed so that a user with a large data matrix (YY) and/or limited core may partition that matrix into sub-matrices, and make multiple calls to SSRAND. Alternatively, where core availability is no problem, the user may enter SSRAND with YY (equal to Y in this case) in its entirety and call SSRAND only once. The SSRAND output is not affected by the manner in which YY is partitioned into submatrices.

See reference:

Cochran, W.G., Sampling Techniques, John Wiley and Sons, New York, 1963, Chapters 6 and 7.

Programming Notes

1. A common usage of SSRAND's core conserving characteristics would be to write the data matrix YY onto disk or tape and then alternately read submatrices, Y, and call SSRAND. For example, a driver for SSRAND could be written as follows for the example given in the Example section below.

```
INTEGER  IY,IOPT,NBR(7),IER
REAL     Y(15,2),ALPHA,TEMP(2),XBAR,B,STAT(18)
IY = 15
READ (from cards) (NBR(I),I=1,7),ALPHA,(TEMP(J),J=1,2),B,IOPT
```

```
      N2 = NBR(2)
      M = (NBR(1)+NBR(2)-1)/NBR(2)
      DO 50 L=1,M
         IF(L.EQ.M) N2 = NBR(1)-(M-1)*N2
         READ (from tape or disk) ((Y(I,1),Y(I,2)), I=1,N2)
         NBR(3) = L
         CALL SSRAND(Y,IY,IOPT,NBR,ALPHA,TEMP,XBAR,B,STAT,IER)
   50 CONTINUE
      WRITE (on printer) (STAT(I),I=1,18)
      .
      .
      .
      END
```

2. The notation used by Cochran (1963) for selected SSRAND calling sequence parameters is given below.

SSRAND Parameter	Union of all Y(=YY)	NBR(1)	NBR(5)	XBAR	B
Cochran's Notation	$\{x_i, y_i\}$	n	N	$\bar{X}$	b_o

Example

Suppose it is desired to compute point and interval estimates of the population mean and total using a random sample of size 36 from a population of size 100. For this case, in the example driver in Programming Notes above, M=3, and thus 3 calls to SSRAND are required to obtain the desired output. SSRAND can be used as follows (where Y^t = Y transpose):

1. CALL SSRAND (Y,IY,IOPT,NBR,ALPHA,TEMP,XBAR,B,STAT,IER)

   Input:

$$Y^t = \begin{bmatrix} 4.7 & 5.0 & 5.2 & 5.2 & 5.9 & 4.7 & 5.9 & 5.2 & 5.3 & 5.9 & 5.6 & 5.0 \\ 3.0 & 3.0 & 4.0 & 5.0 & 6.0 & 4.0 & 9.0 & 3.0 & 7.0 & 6.0 & 6.0 & 4.0 \\ 4.7 & 5.0 & 5.2 \\ 3.0 & 3.0 & 4.0 \end{bmatrix}$$

   IOPT = 0
   NBR = (36,15,1,0,100,-,-)
   ALPHA = 0.05
   TEMP = (5.0,5.0)
   XBAR = 5.2
   B is undefined

2. CALL SSRAND (Y,IY,IOPT,NBR,ALPHA,TEMP,XBAR,B,STAT,IER)

Input:

$$Y^t = \begin{bmatrix} 5.2 & 5.9 & 4.7 & 5.9 & 5.2 & 5.3 & 5.9 & 5.6 & 5.0 & 4.7 & 5.0 & 5.2 \\ 5.0 & 6.0 & 4.0 & 9.0 & 3.0 & 7.0 & 6.0 & 6.0 & 4.0 & 3.0 & 3.0 & 4.0 \end{bmatrix}$$

$$\begin{bmatrix} 5.2 & 5.9 & 4.7 \\ 5.0 & 6.0 & 4.0 \end{bmatrix}$$

IOPT = 0
NBR = (36,15,2,0,100,-,-)
ALPHA = 0.05
TEMP = (5.0,5.0)
XBAR = 5.2
B is undefined

3. CALL SSRAND (Y,IY,IOPT,NBR,ALPHA,TEMP,XBAR,B,STAT,IER)

Input:

$$Y^t = \begin{bmatrix} 5.9 & 5.2 & 5.3 & 5.9 & 5.6 & 5.0 \\ 9.0 & 3.0 & 7.0 & 6.0 & 6.0 & 4.0 \end{bmatrix}$$

IOPT = 0
NBR = (36,15,3,0,100,-,-)
ALPHA = 0.05
TEMP = (5.0,5.0)
XBAR = 5.2
B is undefined

Output:

STAT = (4.9057,490.57,0.040914,409.14,4.5092,5.3021,450.92,530.21,
0.94340,0.0015131,0.86716,1.0196,4.1233,1.3598,6.0159,5.3000,
5.0000,-)

IER = 0

IMSL ROUTINE NAME - SSRBLK

PURPOSE - STRATIFIED RANDOM SAMPLING WITH CONTINUOUS DATA-INFERENCES REGARDING THE POPULATION MEAN AND TOTAL USING RATIO OR REGRESSION ESTIMATION

USAGE - CALL SSRBLK (Y,IY,IOPT,NBR,NH,IN,XBARH,ALPHA, TEMP,BR,HMUSIG,IH,STAT,IER)

ARGUMENTS

Y - INPUT NBR(2) BY 2 SUBMATRIX OF THE MATRIX (CALL IT YY) CONTAINING THE ENTIRE STRATIFIED RANDOM SAMPLE. THE SUBMATRIX Y MUST BE EITHER THE SAME AS YY OR IT MUST CONTAIN ALL OR PART OF THE SAMPLE FOR A SINGLE STRATUM ONLY. IN THE CASE WHERE Y IS A PROPER SUBSET OF YY, THE LAST SUBMATRIX FROM ANY ONE OR MORE OF THE STRATA MAY HAVE FEWER THAN NBR(2) ROWS. IN ALL CASES THE PAIRS OF OBSERVATIONS WITHIN ANY ONE STRATUM MUST APPEAR CONTIGUOUSLY IN YY. THE AUXILIARY VARIABLE SETTINGS ARE IN COLUMN 1 WITH CORRESPONDING VARIABLE OF INTEREST SETTINGS IN COLUMN 2. SEE PROGRAMMING NOTES.

IY - INPUT ROW DIMENSION OF MATRIX Y EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

IOPT - INPUT ESTIMATION OPTION.
- IF IOPT = 0, RATIO ESTIMATION IS TO BE USED FOR INFERENCE ABOUT THE POPULATION MEAN AND TOTAL.
- IF IOPT IS NEGATIVE, REGRESSION ESTIMATION, WITH REGRESSION COEFFICIENT(S) PREASSIGNED VIA BR, IS TO BE USED.
- IF IOPT IS POSITIVE, REGRESSION ESTIMATION, WITH REGRESSION COEFFICIENT(S) ESTIMATED FROM THE DATA, IS TO BE USED

NBR - INPUT VECTOR OF LENGTH 9. NBR(I) CONTAINS WHEN
- I=1, NUMBER OF STRATA INTO WHICH THE SAMPLE IS DIVIDED.
- I=2, NUMBER OF PAIRS OF OBSERVATIONS IN EACH SUBMATRIX Y, NOT INCLUDING THE LAST SUBMATRIX IN EACH STRATUM, WHERE THE NUMBER MAY BE LESS THAN OR EQUAL TO NBR(2). HOWEVER NBR(2) SHOULD BE THE SAME FOR ALL CALLS.
- I=3, THE NUMBER OF THE SUBMATRIX STORED IN Y. SEE REMARKS.
- I=4, THE TEMPORARY MEAN INDICATOR. IF NBR(4) = 0, THE USER SUPPLIES TEMPORARY MEANS IN TEMP. THE USER MAY CHANGE TEMP ONLY WHEN SUBMATRIX Y IS THE FIRST SET OF OBSERVATIONS IN A STRATUM. IF NBR(4) DOES NOT EQUAL ZERO, THE FIRST PAIR OF OBSERVATIONS IN EACH STRATUM IS UTILIZED.

I=5, OPTION FOR A SEPARATE OR COMBINED ESTIMATION TECHNIQUE. IF NBR(5) = 0, SEPARATE RATIO OR REGRESSION ESTIMATION IS TO BE USED. OTHERWISE A COMBINED ESTIMATION TECHNIQUE IS UTILIZED.
I=(6-9), INTEGER WORK AREA.

NH - INPUT NBR(1) BY 3 MATRIX CONTAINING THE NUMBER OF PAIRS OF SAMPLE UNITS IN EACH STRATUM FOR THE SAMPLE (MATRIX YY) AND FOR THE POPULATION. THE STRATA SIZES FOR THE SAMPLE AND THE POPULATION ARE IN COLUMNS 1 AND 2 RESPECTIVELY. THE STRATA SIZES MUST BE ORDERED IN CORRESPONDENCE WITH THE ORDERING OF STRATA IN YY. IN THE CASE WHERE POPULATION STRATA SIZES ARE NOT KNOWN, ESTIMATES MUST BE ENTERED IN THEIR PLACE. COLUMN 3 IS WORK STORAGE.

IN - INPUT ROW DIMENSION OF MATRIX NH EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

XBARH - INPUT VECTOR OF LENGTH NBR(1) CONTAINING, FOR EACH STRATUM, THE POPULATION MEAN OF THE AUXILIARY VARIATE, PROVIDED NBR(5) = 0. OTHERWISE, ONLY XBARH(1) IS DEFINED AND IT MUST CONTAIN THE POPULATION MEAN OF THE AUXILIARY VARIATE.

ALPHA - INPUT VALUE IN THE EXCLUSIVE INTERVAL (0,1) USED FOR COMPUTING 100(1-ALPHA) PERCENT CONFIDENCE INTERVALS FOR THE MEAN AND TOTAL PARAMETERS.

TEMP - INPUT VECTOR OF LENGTH 2. IF NBR(4) = 0, TEMP MUST CONTAIN TEMPORARY MEANS FOR THE TWO COLUMNS OF YY, RESPECTIVELY. OTHERWISE TEMP IS UNDEFINED.

BR - INPUT/OUTPUT VECTOR OF LENGTH NBR(1).
IF IOPT IS NEGATIVE, BR IS DEFINED ONLY ON INPUT. WHEN NBR(5) = 0, BR CONTAINS A PREASSIGNED REGRESSION COEFFICIENT FOR EACH STRATUM. WHEN NBR(5) IS NONZERO, ONLY BR(1) IS DEFINED AND MUST CONTAIN THE PREASSIGNED REGRESSION COEFFICIENT COMMON TO ALL STRATA.
IF IOPT IS POSITIVE, BR IS DEFINED ONLY ON OUTPUT. WHEN NBR(5) = 0, BR CONTAINS THE ESTIMATED REGRESSION COEFFICIENT FOR EACH STRATUM. WHEN NBR(5) IS NONZERO, ONLY BR(1) IS DEFINED AND CONTAINS THE ESTIMATED REGRESSION COEFFICIENT COMMON TO ALL STRATA.
IF IOPT = 0, BR IS DEFINED ONLY ON OUTPUT. WHEN NBR(5) = 0, BR CONTAINS THE ESTIMATE OF THE RATIO FOR EACH STRATUM. WHEN NBR(5) IS NONZERO, ONLY BR(1) IS DEFINED AND CONTAINS THE COMBINED ESTIMATE OF THE RATIO.

HMUSIG - OUTPUT NBR(1) BY 6 MATRIX CONTAINING THE WITHIN STRATA MEAN ESTIMATES, VARIANCE ESTIMATES AND COEFFICIENT OF VARIATION OF THE MEAN ESTIMATES. THE ESTIMATES FOR THE AUXILIARY VARIABLE ARE IN COLUMNS 1, 2, AND 3 RESPECTIVELY. THE CORRESPONDING ESTIMATES FOR THE VARIABLE OF INTEREST SETTINGS ARE IN COLUMNS 4, 5, AND 6, RESPECTIVELY. THE ESTIMATES ARE ORDERED IN CORRESPONDENCE WITH THE ORDERING OF STRATA IN YY.

IH - INPUT ROW DIMENSION OF MATRIX HMUSIG EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

STAT - OUTPUT VECTOR OF LENGTH 20. STAT(I) CONTAINS WHEN

- I=1, ESTIMATE OF THE MEAN.
- I=2, ESTIMATE OF THE TOTAL.
- I=3, VARIANCE ESTIMATE OF THE MEAN ESTIMATE.
- I=4, VARIANCE ESTIMATE OF THE TOTAL ESTIMATE.
- I=5, LOWER CONFIDENCE LIMIT FOR THE MEAN.
- I=6, UPPER CONFIDENCE LIMIT FOR THE MEAN.
- I=7, LOWER CONFIDENCE LIMIT FOR THE TOTAL.
- I=8, UPPER CONFIDENCE LIMIT FOR THE TOTAL.
- I=9, ESTIMATE OF THE COEFFICIENT OF VARIATION OF THE MEAN AND TOTAL ESTIMATES.
- I=10, ESTIMATE OF THE MEAN FOR THE AUXILIARY VARIATE, CONSIDERING ONLY THE DATA IN COLUMN 1 OF YY. DEFINED ONLY WHEN NBR(5) IS NONZERO.
- I=11, ESTIMATE OF THE MEAN FOR THE VARIABLE OF INTEREST, CONSIDERING ONLY THE DATA IN COLUMN 2 OF YY. DEFINED ONLY WHEN NBR(5) IS NONZERO.
- I=12-20, WORK AREA.

IER - ERROR PARAMETER. (OUTPUT)

WARNING ERROR

IER = 33 INDICATES THE MAXIMUM ELEMENT IN COLUMN 3 OF HMUSIG TIMES THE SQUARE ROOT OF NBR(1) EXCEEDS 30, WHEN NBR(5) = 0. WHEN NBR(5) IS NONZERO, THIS INDICATES THE ESTIMATE OF THE COEFFICIENT OF VARIATION OF STAT(10) EXCEEDS 10. IN EITHER CASE THE BIAS IN THE ESTIMATES STAT(1) AND STAT(2) MAY NOT BE NEGLIGIBLE.

TERMINAL ERROR

IER = 130 INDICATES NBR(1) IS LESS THAN 2 OR THAT NBR(2) IS LESS THAN 1.

IER = 131 INDICATES NBR(3) IS LESS THAN 1 OR THAT NBR(2)*(NBR(3)-NBR(1)) EXCEEDS THE NUMBER OF PAIRS OF ELEMENTS IN YY (TOTAL OF COLUMN 1 OF NH).

IER = 132 INDICATES THAT AT LEAST ONE ELEMENT OF COLUMN 1 OF NH IS LESS THAN 3 OR THAT AT LEAST ONE ELEMENT IN COLUMN 2 IS LESS THAN THE ELEMENT IN THE SAME ROW IN COLUMN 1.
IER = 133 INDICATES THAT ALPHA IS NOT IN THE EXCLUSIVE INTERVAL (0,1).
IER = 134 INDICATES THAT NBR(2) EXCEEDS THE TOTAL OF COLUMN 1 OF NH, THE TOTAL SAMPLE SIZE. WHEN NBR(2) IS LESS THAN THE TOTAL SAMPLE SIZE, IER=134 INDICATES THAT NBR(2) IS GREATER THAN SOME NH(I,1),I=1,2,...,NBR(1).

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - MDNRIS,MERFI,UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS BETWEEN THE FIRST AND LAST CALL TO SSRBLK, EXCEPT FOR OPTIONALLY CHANGING TEMP BETWEEN STRATA, ONLY NBR(3) MAY BE MODIFIED AND IT SHOULD FOLLOW THE PATTERN 1,2,... . THOUGH THIS PATTERN IS THE OBVIOUS ONE TO FOLLOW, IT IS NOT NECESSARY IN ITS ENTIRETY. FOR THE FIRST AND LAST SUBMATRIX WITHIN EACH STRATUM, NBR(3) MUST HAVE ITS CORRECT PATTERN VALUE. FOR THE INTERMEDIATE SUBMATRICES WITHIN EACH STRATUM, NBR(3) MAY TAKE ANY VALUE BETWEEN THE CORRESPONDING FIRST AND LAST SUBMATRIX NBR(3) VALUES.

Algorithm

Let L=NBR(1), n_h=NH(h,1), $R = \sum_{h=1}^{L} n_h$, r_h=greatest integer in $(n_h+NBR(2)-1)/NBR(2)$, and $r = \sum_{h=1}^{L} r_h$. Then, given an R by 2 matrix (call it YY) containing the stratified random sample, SSRBLK computes point and interval estimates for the population mean and total, with options on the choice of estimation technique. Only a submatrix, Y, of YY is available to the routine at any one time and the results are available only after SSRBLK has been called for the r-th time. (If NBR(2)=R, r=1.) Y is comprised of a set of rows of YY such that Y never includes observations from more than one stratum (unless NBR(2)=R), which are presented, in order, to Y through the call.

Let (x_{hi},y_{hi}) be the i-th observation in stratum h in submatrix Y, where Y is a submatrix of YY, for $i=1,2,\ldots,n_h$; $h=1,2,\ldots,L$.

Let (T_{xh},T_{yh})=(TEMP(1),TEMP(2)) for stratum h and let $s_{hi}=x_{hi}-T_{xh}$ and $t_{hi}=y_{hi}-T_{yh}$, for i and h as in the definition of (x_{hi},y_{hi}), above.

Then

$$\bar{x}_h = \sum_{i=1}^{n_h} x_{hi}/n_h$$

$$\bar{y}_h = \sum_{i=1}^{n_h} y_{hi}/n_h$$

$$(n_h-1)s_{xh}^2 = \sum_{i=1}^{n_h} s_{hi}^2 - n_h(\bar{x}_h-T_{xh})^2$$

$$(n_h-1)s_{yh}^2 = \sum_{i=1}^{n_h} t_{hi}^2 - n_h(\bar{y}_h-T_{yh})^2$$

$$(n_h-1)s_{xyh} = \sum_{i=1}^{n_h} (s_{hi})(t_{hi}) - n_h(\bar{x}_h-T_{xh})(\bar{y}_h-T_{yh})$$

In general, more than one submatrix Y will contain observations in a single stratum, and thus, in the code, the summations above are also over multiple submatrices.

The remaining computations depend on the above and are described in Chapters 6 and 7 of the reference below.

SSRBLK is designed so that a user with a large data matrix (YY) and/or limited core may partition that matrix into submatrices, and make multiple calls to SSRBLK subject to the restriction that no submatrix may contain data from more than one stratum. Alternatively, where core availability is no problem, the user may enter SSRBLK with YY (equal to Y in this case) in its entirety and call SSRBLK only once.

See reference:

Cochran, W. G., Sampling Techniques, John Wiley and Sons, New York, 1963, Chapters 6 and 7.

Programming Notes

1. A common usage of SSRBLK's core conserving characteristics would be to write the data matrix YY onto disk or tape and then alternately read submatrices, Y, and call SSRBLK. For example, a driver for SSRBLK could be written as follows for the example given in the Example section below. The example illustrates a case in which YY is partitioned into three submatrices. Dimensioning in the listing below is set for Case 1. Obvious changes are needed for Case 2.

```
      INTEGER  IY,IOPT,NBR(9),NH(2,3),IN,IH,IER
      REAL     Y(4,2),ALPHA,HMUSIG(2,6),TEMP(2),BR(2),XBARH(2),STAT(20)
      IY=4
      IN=2
      IH=2
      READ (from cards) (NBR(I),I=1,5),IOPT,ALPHA
      N1=NBR(1)
      N2=NBR(2)
      READ (from cards) ((NH(I,J),I=1,N1),J=1,2)
      N=0
C                                   COMPUTE THE TOTAL NO. OF OBSERVATIONS
      DO 5 I=1,N1
        N=N+NH(I,1)
    5 CONTINUE
      IF (N2.NE.N) GO TO 10
      MM=1
      GO TO 20
   10 MM=0
      DO 15 I=1,N1
        NH(I,3)=(NH(I,1)+N2-1)/N2
        MM=MM+NH(I,3)
        IF (I.EQ.1) GO TO 15
        NH(I,3)=NH(I-1,3)+NH(I,3)
   15 CONTINUE
   20 L=1
      DO 30 M=1,MM
        NBR(3)=M
        NN=N2
        IF (MM.EQ.1) GO TO 25
        NS=NH(L,3)-1
        IF (M.NE.1 .AND. L.NE.1) NS=NH(L,3)-NH(L-1,3)-1
        IF (M.NE.NH(L,3)) GO TO 25
        NN=NH(L,1)-NS*NN
        L=L+1
   25   READ (from cards) ((Y(I,J),J=1,2),I=1,NN)
        IF (NBR(4).EQ.0) READ (from cards) (TEMP(I),I=1,2)
        IF(NBR(5).EQ.0) READ (from cards) (XBARH(I),I=1,N1)
        IF(NBR(5).NE.0) READ (from cards) XBARH(1)
        CALL SSRBLK(Y,IY,IOPT,NBR,NH,IN,XBARH,ALPHA,TEMP,BR,HMUSIG,
     *  IH,STAT,IER)
   30 CONTINUE
      WRITE (on printer) ((HMUSIG(I,J),I=1,N1),J=1,6)
      WRITE (on printer) (STAT(I),I=1,11)
       .
       .
       .
      END
```

2. The notation used by Cochran (1963) for selected SSRBLK calling sequence parameters is given below.

SSRBLK Parameter	Union of all Y(=YY)	NBR(1)	NH(h,1)	NH(h,2)	HMUSIG (h,1)	HMUSIG (h,2)	HMUSIG (h,4)	HMUSIG (h,5)
Cochran's Notation	$\{x_{hi}, y_{hi}\}$	L	n_h	N_h	$\bar{x}_h$	s^2_{xh}	$\bar{y}_h$	s^2_{yh}

HMUSIG(h,3) = 100*SQRT(HUMUSIG(h,2))/A, where A = HUMUSIG(h,1) if combined and = XBARH(h) if separate.

HUMUSIG(h,6) = 100*$\sqrt{\text{HUMUSIG(h,5)}}$/HUMUSIG(h,4)

3. SSRBLK allows three basic estimation procedures as indicated by option parameter IOPT. Either a separate or combined technique may be utilized with each, as indicated by option parameter NBR(5), yielding a total of six possibilities.

Certain calling sequence parameters XBARH, BR, STAT(10), and STAT(11), may or may not be defined as controlled by the option parameters. The following table indicates when these parameters are defined.

IOPT	NBR(5)	Selected Parameters	
		Required Input	Output
Zero	Zero	XBARH	BR
	Nonzero	XBARH(1)	BR(1) STAT(10) STAT(11)
Negative	Zero	XBARH BR	
	Nonzero	XBARH(1) BR(1)	STAT(10) STAT(11)
Positive	Zero	XBARH	BR
	Nonzero	XBARH(1)	BR(1) STAT(10) STAT(11)

Example

Case 1:

Suppose it is desired to compute point and interval estimates of the population mean and total using a stratified random sample of size 10 from a population of size 100 and a combined ratio estimation technique. Assume there are two strata and the corresponding strata sample and population sizes are (6,4) and (60,40), respectively. For this case, in the example driver in Programming Notes above, NH(1,1)=6 and NH(2,1)=4. Assume that the sample is input four observations at a time, i.e. NBR(2)=4. Thus, three calls to SSRBLK are required to obtain the desired output.

1. CALL SSRBLK(Y,IY,IOPT,NBR,NH,IN,XBARH,ALPHA,TEMP,BR,HMUSIG,IH, STAT,IER)

Input:

$$Y^t = \begin{bmatrix} 100. & 101. & 102. & 101. \\ 75. & 71. & 70. & 73. \end{bmatrix}$$

where Y^t=Y transpose

IOPT = 0
NBR = (2,4,1,1,1)

$$NH = \begin{bmatrix} 6 & 60 & - \\ 4 & 40 & - \end{bmatrix}$$

XBARH = (100.,-)
ALPHA = 0.10
TEMP and BR are undefined

2. CALL SSRBLK(Y,IY,IOPT,NBR,NH,IN,XBARH,ALPHA,TEMP,BR,HMUSIG,IH, STAT,IER)

Input:

Same as the first call except

$$Y^t = \begin{bmatrix} 101. & 101. \\ 76. & 72. \end{bmatrix}$$

NBR(3)= 2

3. CALL SSRBLK(Y,IY,IOPT,NBR,NH,IN,XBARH,ALPHA,TEMP,BR,HMUSIG,IH, STAT,IER)

Input:

Same as the first call except

$$Y^t = \begin{bmatrix} 96. & 98. & 99. & 99. \\ 68. & 65. & 65. & 64. \end{bmatrix}$$

NBR(3)= 3

Output:

BR = (0.70040, -)

$$HMUSIG = \begin{bmatrix} 101.00 & 0.40000 & 0.25564 & 72.833 & 5.3667 & 1.2985 \\ 98.000 & 2.0000 & 0.72154 & 65.500 & 3.0000 & 1.3222 \end{bmatrix}$$

STAT = (70.040, 7004.008, .637, 6370.254, 68.727, 71.353, 6872.727, 7135.289, 1.140, 99.800, 69.900)

IER = 0

Case 2:

Usage of SSRBLK is simplified if the sample data is entered in its entirety and SSRBLK is called only once. This mode of usage is illustrated below for the same data as in Case 1.

Input:

$$Y^t = \begin{bmatrix} 100. & 101. & 102. & 101. & 101. & 101. & 96. & 98. & 99. & 99. \\ 75. & 71. & 70. & 73. & 76. & 72. & 68. & 65. & 65. & 64. \end{bmatrix}$$

IOPT = 0
NBR = (2,10,1,1,1)

$$NH = \begin{bmatrix} 6 & 60 & - \\ 4 & 40 & - \end{bmatrix}$$

XBARH = (100.,-)
ALPHA = 0.10
TEMP and BR are undefined

Output:

Same as in Case 1.

IMSL ROUTINE NAME - SSSAND

PURPOSE - SIMPLE RANDOM SAMPLING WITH CONTINUOUS DATA - INFERENCES REGARDING THE POPULATION MEAN AND TOTAL

USAGE - CALL SSSAND (Y,NBR,ALPHA,TEMP,STAT,IER)

ARGUMENTS

Y - INPUT SUBVECTOR OF LENGTH NBR(2) OF THE VECTOR (CALL IT YY) CONTAINING THE ENTIRE RANDOM SAMPLE. THE LAST SUBVECTOR OF YY MAY HAVE FEWER THAN NBR(2) ELEMENTS.

NBR - INPUT VECTOR OF LENGTH 8. NBR(I) CONTAINS, WHEN
- I=1, NUMBER OF OBSERVATIONS IN YY.
- I=2, NUMBER OF OBSERVATIONS IN EACH SUBVECTOR Y, NOT INCLUDING THE LAST SUBVECTOR, WHERE THE NUMBER MAY BE LESS THAN OR EQUAL TO NBR(2). HOWEVER NBR(2) SHOULD BE THE SAME FOR ALL CALLS.
- I=3, THE NUMBER OF THE SUBVECTOR STORED IN Y. SEE REMARKS.
- I=4, THE TEMPORARY MEAN INDICATOR. IF NBR(4) = 0, THE USER SUPPLIES THE TEMPORARY MEAN IN TEMP. OTHERWISE, THE FIRST ELEMENT OF YY (OR FIRST ELEMENT OF Y WHEN NBR(3) = 1) IS UTILIZED.
- I=5, SUBPOPULATION INDICATOR.
  - IF NBR(5) = 0, THE INPUT DATA IS A SAMPLE FROM A POPULATION.
  - IF NBR(5) IS NEGATIVE THE SAMPLE IS FROM A SUBPOPULATION OF UNKNOWN SIZE.
  - IF NBR(5) IS POSITIVE THE SAMPLE IS FROM A SUBPOPULATION OF KNOWN SIZE.
- I=6, SIZE OF THE SAMPLED POPULATION. NOT REQUIRED IF NBR(5) IS POSITIVE.
- I=7, SIZE OF THE SAMPLED SUBPOPULATION. REQUIRED ONLY WHEN NBR(5) IS POSITIVE.
- I=8, SIZE OF THE SAMPLE FROM THE POPULATION FOR WHICH NBR(1) WERE TAKEN TO CONSTITUTE THE SAMPLE FROM THE SUBPOPULATION OF INTEREST. REQUIRED ONLY WHEN NBR(5) IS NEGATIVE.

ALPHA - INPUT VALUE IN THE EXCLUSIVE INTERVAL (0,1) USED FOR COMPUTING 100(1-ALPHA) PERCENT CONFIDENCE INTERVALS FOR THE MEAN AND TOTAL PARAMETERS. 0.05 IS A COMMON CHOICE.

TEMP - INPUT TEMPORARY MEAN. REQUIRED ONLY IF NBR(4) = 0.

STAT - OUTPUT VECTOR OF LENGTH 9. STAT(I) CONTAINS, WHEN
- I=1, ESTIMATE OF THE MEAN.
- I=2, ESTIMATE OF THE TOTAL.
- I=3, WITHIN SAMPLE VARIANCE ESTIMATE.
- I=4, VARIANCE ESTIMATE OF THE MEAN ESTIMATE.

I=5, VARIANCE ESTIMATE OF THE TOTAL ESTIMATE
I=6, LOWER CONFIDENCE LIMIT FOR THE MEAN.
I=7, UPPER CONFIDENCE LIMIT FOR THE MEAN.
I=8, LOWER CONFIDENCE LIMIT FOR THE TOTAL.
I=9, UPPER CONFIDENCE LIMIT FOR THE TOTAL.

IER - ERROR PARAMETER. (OUTPUT)
TERMINAL ERROR
IER = 129 INDICATES ONE OR MORE OF NBR(1), NBR(6) (WHEN NBR(5) IS NONPOSITIVE), NBR(7) (WHEN NBR(5) IS POSITIVE), AND NBR(8) (WHEN NBR(5) IS NEGATIVE), ARE LESS THAN 2.
IER = 130 INDICATES NBR(3) IS LESS THAN ONE OR THAT NBR(2)*(NBR(3)-1) EXCEEDS NBR(1).
IER = 131 INDICATES THAT NBR(2) IS LESS THAN 1 OR THAT ALPHA IS NOT IN THE EXCLUSIVE INTERVAL (0,1).

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - MDNRIS,MDSTI,MERFI,UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS BETWEEN THE FIRST CALL AND THE LAST CALL (M-TH CALL) TO SSSAND ONLY NBR(3) MAY BE MODIFIED AND IT SHOULD FOLLOW THE PATTERN 1,2,...,M. THOUGH THIS PATTERN IS THE OBVIOUS ONE TO FOLLOW, IT IS NOT NECESSARY IN ITS ENTIRETY. FOR CALLS 2,3,...,M-1, NBR(3) MAY TAKE ANY VALUE IN THE SET (2,3,...,M-1). ON THE FIRST CALL NBR(3) MUST EQUAL 1, AND ON THE LAST CALL NBR(3) MUST EQUAL M.

Algorithm

Let (NBR(1),NBR(2))=(R,r). Then, given a vector (call it YY) of length R containing the random sample, SSSAND computes point and interval estimates of the population mean and total, with options on the presence or absence of a subpopulation and on whether or not the subpopulation size is known. Only a subvector, Y, of YY is available to the routine at any one time and the results are available only after SSSAND has been called for the m-th time where m is the greatest integer in (R+r-1)/r, and r is the number of elements in subvector Y. Y is comprised of a set of elements of YY, which are presented, in order, to Y through the call.

Let $y_i^{(k)}$ be the i-th observation in subvector Y, where Y is the k-th subvector in YY, for i=1,2,...,n; k=1,2,...,m; and

$$n=\begin{cases} r & , k=1,2,\ldots,m-1 \\ R-(m-1)r, & k=m \end{cases}$$

Let T=TEMP and let $t_i^{(k)}=y_i^{(k)}-T$, for i and k as in the definition of $y_i^{(k)}$, above. Then

$$\bar{y} = \text{STAT}(1) = \left\{ \sum_{k=1}^{m} \sum_{i=1}^{n} y_i^{(k)} \right\} \Big/ R;$$

and

$$s^2 = \text{STAT}(3) = \frac{\sum_{k=1}^{m} \sum_{i=1}^{n} [t_i^{(k)}]^2 - R(\bar{y}-T)^2}{R-1}$$

The remaining computations depend on the above and are described in Chapter 2 of the reference below.

SSSAND is designed so that a user with a large data vector (YY) and/or limited core may partition that vector into subvectors, and make multiple calls to SSSAND. Alternatively, where core availability is no problem, the user may enter SSSAND with YY (equal to Y in this case) in its entirety and call SSSAND only once.

See reference:

Cochran, W.G., Sampling Techniques, John Wiley and Sons, New York, 1963, Chapter 2.

Programming Notes

1. Some minimization of round-off error may occur if Y is made as large as possible (i.e., the number of subvectors is minimized).

2. A common usage of SSSAND's core conserving characteristics would be to write the data vector YY onto tape or disk and then alternately read subvectors, Y, and call SSSAND. For example, a driver for SSSAND could be written as follows for the example given in the Example section below. The example illustrates the special case YY=Y.

```
      INTEGER NBR(8),IER
      REAL    Y(15),ALPHA,TEMP,STAT(9)
      .
      .
      .
      READ (from cards) (NBR(I),I=1,8),ALPHA,TEMP
      N2=NBR(2)
      M=(NBR(1)+NBR(2)-1)/NBR(2)
      DO 50 L=1,M
         IF(L .EQ. M)  N2=NBR(1)-(M-1)*N2
         READ (from tape or disk) (Y(I),I=1,N2)
         NBR(3)=L
         CALL SSSAND(Y,NBR,ALPHA,TEMP,STAT,IER)
   50 CONTINUE
      WRITE (on printer) (STAT(I),I=1,9)
      .
      .
      .
      END
```

3. The notation used by Cochran (1963) for selected SSSAND calling sequence parameters is given below.

SSSAND Parameter	Union of all Y(=YY)	NBR(1) NBR(5)=0	NBR(1) Nonzero NBR(5)	NBR(6)	NBR(7)	NBR(8)
Cochran's Notation	$\{y_i\}$	n	n_j	N	N_j	n

Example

Suppose it is desired to compute point and interval estimates of the population mean and total using a random sample of size 15 from a population of size 150. SSSAND may be used as follows based on the driver specified in Programming Notes above.

Input:

```
Y     = (21.0,14.0,17.0,22.0,19.0,21.0,20.0,15.0,24.0,28.0,20.0,17.0,
         16.0,22.0,19.0)
NBR   = (15,15,1,0,0,150,-,-)
ALPHA =  0.05
TEMP  =  20.0
```

Output:

```
STAT  = (19.667,2950.0,13.238,0.79429,17871.,17.755,21.578,2663.3,3236.7)
IER   =  0
```

IMSL ROUTINE NAME - SSSBLK

PURPOSE - STRATIFIED RANDOM SAMPLING WITH CONTINUOUS DATA - INFERENCES REGARDING THE POPULATION MEAN AND TOTAL

USAGE - CALL SSSBLK (Y,NBR,NH,IN,ALPHA,TEMP,HMUSIG, IH,STAT,IER)

ARGUMENTS

Y - INPUT SUBVECTOR OF LENGTH NBR(2) OF THE VECTOR (CALL IT YY) CONTAINING THE ENTIRE STRATIFIED RANDOM SAMPLE. THE SUBVECTOR Y MUST BE EITHER THE SAME AS YY OR IT MUST CONTAIN ALL OR PART OF THE SAMPLE FOR A SINGLE STRATUM ONLY. IN THE CASE WHERE Y IS A PROPER SUBSET OF YY, THE LAST SUBVECTOR FROM ANY ONE OR MORE OF THE STRATA MAY HAVE FEWER THAN NBR(2) ELEMENTS. IN ALL CASES THE OBSERVATIONS WITHIN ANY ONE STRATUM MUST APPEAR CONTIGUOUSLY IN YY.

NBR - INPUT VECTOR OF LENGTH 5. NBR(I) CONTAINS, WHEN

I=1, NUMBER OF STRATA INTO WHICH THE SAMPLE IS DIVIDED.

I=2, NUMBER OF OBSERVATIONS IN EACH SUBVECTOR Y, NOT INCLUDING THE LAST SUBVECTOR IN EACH STRATUM, WHERE THE NUMBER MAY BE LESS THAN OR EQUAL TO NBR(2). HOWEVER, NBR(2) SHOULD BE THE SAME FOR ALL CALLS.

I=3, THE NUMBER OF THE SUBVECTOR STORED IN Y. SEE REMARKS.

I=4, THE TEMPORARY MEAN INDICATOR. IF NBR(4) = 0, THE USER SUPPLIES THE TEMPORARY MEAN IN TEMP. THE USER MAY CHANGE TEMP ONLY WHEN SUBVECTOR Y IS THE FIRST SET OF OBSERVATIONS IN A STRATUM. IF NBR(4) DOES NOT EQUAL ZERO, THE FIRST ELEMENT IN EACH STRATUM IS USED AS THE TEMPORARY MEAN FOR THE DATA IN THAT STRATUM.

I=5, THE WITHIN STRATUM VARIANCE ASSUMPTION INDICATOR.

IF NBR(5) = 0, THE TRUE WITHIN STRATUM VARIANCE IS ASSUMED CONSTANT, AND A POOLED ESTIMATE OF THAT VARIANCE IS RETURNED IN HMUSIG(1,2).

IF NBR(5) IS NONZERO, SEPARATE WITHIN STRATA VARIANCE ESTIMATES ARE COMPUTED AND RETURNED IN COLUMN 2 OF HMUSIG.

NH - INPUT NBR(1) BY 3 MATRIX CONTAINING THE NUMBER OF SAMPLE UNITS IN EACH STRATUM FOR THE SAMPLE (VECTOR YY) AND FOR THE POPULATION. THE STRATA SIZES FOR THE SAMPLE AND THE POPULATION ARE IN COLUMNS 1 AND 2, RESPECTIVELY. THE STRATA SIZES MUST BE ORDERED IN

CORRESPONDENCE WITH THE ORDERING OF STRATA IN YY. IN THE CASE WHERE POPULATION STRATA SIZES ARE NOT KNOWN, ESTIMATES MUST BE ENTERED IN THEIR PLACE. COLUMN 3 IS WORK STORAGE.

IN - INPUT ROW DIMENSION OF MATRIX NH EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

ALPHA - INPUT VALUE IN THE EXCLUSIVE INTERVAL (0,1) USED FOR COMPUTING 100(1-ALPHA) PERCENT CONFIDENCE INTERVALS FOR THE MEAN AND TOTAL PARAMETERS.

TEMP - INPUT TEMPORARY MEAN. REQUIRED ONLY IF NBR(4) = 0.

HMUSIG - OUTPUT NBR(1) BY 2 MATRIX CONTAINING THE WITHIN STRATA MEAN AND VARIANCE ESTIMATES. THE MEANS AND VARIANCES ARE IN COLUMNS 1 AND 2, RESPECTIVELY. THE ESTIMATES ARE ORDERED IN CORRESPONDENCE WITH THE ORDERING OF STRATA IN YY. IN THE CASE NBR(5) = 0, ONLY ELEMENT HMUSIG(1,2) OF COLUMN 2 IS DEFINED, AND IT CONTAINS THE POOLED WITHIN STRATA VARIANCE ESTIMATE.

IH - INPUT ROW DIMENSION OF MATRIX HMUSIG EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

STAT - OUTPUT VECTOR OF LENGTH 11. STAT(I) CONTAINS, WHEN

I=1, ESTIMATE OF THE MEAN.
I=2, ESTIMATE OF THE TOTAL.
I=3, VARIANCE ESTIMATE OF THE MEAN ESTIMATE.
I=4, VARIANCE ESTIMATE OF THE TOTAL ESTIMATE
I=5, LOWER CONFIDENCE LIMIT FOR THE MEAN.
I=6, UPPER CONFIDENCE LIMIT FOR THE MEAN.
I=7, LOWER CONFIDENCE LIMIT FOR THE TOTAL.
I=8, UPPER CONFIDENCE LIMIT FOR THE TOTAL.
I=9, ESTIMATE OF THE COEFFICIENT OF VARIATION OF THE MEAN AND TOTAL ESTIMATES.
I=10, NUMBER OF DEGREES OF FREEDOM ASSOCIATED WITH THE VARIANCE ESTIMATES OF THE MEAN AND TOTAL ESTIMATES. WHEN NBR(5) IS NONZERO, STAT(10) CONTAINS AN EFFECTIVE NUMBER OF DEGREES OF FREEDOM DETERMINED ACCORDING TO THE SATTERTHWAITE APPROXIMATION.
I=11, VARIANCE ESTIMATE OF THE MEAN ESTIMATE ASSUMING THAT SAMPLING WAS SIMPLE RANDOM INSTEAD OF STRATIFIED RANDOM.

IER - ERROR PARAMETER. (OUTPUT)
TERMINAL ERROR

IER = 129 INDICATES NBR(1) IS LESS THAN 2 OR THAT NBR(2) IS LESS THAN 1.
IER = 130 INDICATES NBR(3) IS LESS THAN 1 OR THAT NBR(2)*(NBR(3)-NBR(1)) EXCEEDS THE NUMBER (TOTAL OF COLUMN 1 OF NH) OF ELEMENTS IN YY.

IER = 131 INDICATES THAT AT LEAST ONE ELEMENT OF COLUMN 1 OF NH IS LESS THAN 2 OR THAT AT LEAST ONE ELEMENT IN COLUMN 2 IS LESS THAN THE ELEMENT IN THE SAME ROW IN COLUMN 1.
IER = 132 INDICATES THAT ALPHA IS NOT IN THE EXCLUSIVE INTERVAL (0,1) OR THAT A TERMINAL ERROR OCCURRED IN IMSL ROUTINE MDSTI.
IER = 133 INDICATES THAT NBR(2) IS GREATER THAN SOME NH(I,1),I=1,...,NBR(1) WHEN NBR(2) IS LESS THAN THE TOTAL SAMPLE SIZE, OR THAT NBR(2) EXCEEDS THE TOTAL SAMPLE SIZE.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - MDNRIS,MDSTI,MERFI,UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS BETWEEN THE FIRST AND LAST CALL TO SSSBLK, EXCEPT FOR OPTIONALLY CHANGING TEMP BETWEEN STRATA, ONLY NBR(3) MAY BE MODIFIED AND IT SHOULD FOLLOW THE PATTERN 1,2,... . THOUGH THIS PATTERN IS THE OBVIOUS ONE TO FOLLOW, IT IS NOT NECESSARY IN ITS ENTIRETY. FOR THE FIRST AND LAST SUBVECTOR WITHIN EACH STRATUM, NBR(3) MUST HAVE ITS CORRECT PATTERN VALUE. FOR THE INTERMEDIATE SUBVECTORS WITHIN EACH STRATUM, NBR(3) MAY TAKE ANY VALUE BETWEEN THE CORRESPONDING FIRST AND LAST SUBVECTOR NBR(3) VALUES.

Algorithm

Let L=NBR(1), n_h=NH(h,1), $R = \sum_{h=1}^{L} n_h$, r_h= greatest integer in $(n_h+NBR(2)-1)/NBR(2)$, and $r = \sum_{h=1}^{L} r_h$. Then, given a vector (call it YY of length R containing the stratified random sample, SSSBLK computes point and interval estimates for the population mean and total. On option, the population variance within each stratum may be assumed constant. Only a subvector, Y, of YY is available to the routine at any one time and the results are available only after SSSBLK has been called for the r-th time. (If NBR(2)=R, r=1.) Y is comprised of a set of elements of YY, such that Y never includes elements from more than one stratum (unless NBR(2)=R), which are presented, in order, to Y through the call.

Let y_{hi} be the i-th observation in stratum h in subvector Y, where Y is a subvector of YY, for $i=1,2,\ldots,n_h$; $h=1,2,\ldots,L$.

Let T_h=TEMP for stratum h and let $t_{hi}=y_{hi}-T_h$, for i and h as in the definition of y_{hi}, above. Then

$$\bar{y}_h = \text{HMUSIG}(h,1) = \sum_{i=1}^{n_h} y_{hi}/n_h$$

$$(n_h-1)s_h^2 = \sum_{i=1}^{n_h} t_{hi}^2 - n_h(\bar{y}_h-T_h)^2$$

In general, more than one subvector Y will contain observations in a single stratum, and thus, in the code, the summations above are also over multiple subvectors.

The remaining computations depend on the above and are described in Chapters 5 and 5A of the reference below.

SSSBLK is designed so that a user with a large data vector (YY) and/or limited core may partition that vector into subvectors, and make multiple calls to SSSBLK, subject to the restriction that no subvector may contain data from more than one stratum. Alternatively, where core availability is no problem, the user may enter SSSBLK with YY (equal to Y in this case) in its entirety and call SSSBLK only once.

See reference:

Cochran, W. G., Sampling Techniques, John Wiley and Sons, New York, 1963, Chapters 5 and 5A.

Programming Notes

1. A common usage of SSSBLK's core conserving characteristics would be to write the data vector YY onto disk or tape and then alternately read subvectors, Y, and call SSSBLK. For example, a driver for SSSBLK could be written as follows for the example given in the Example section below. The example illustrates a case in which YY is partitioned into three subvectors. Dimensioning in the listing below is set for Case 1. Obvious changes are needed for Case 2.

```
      INTEGER    NBR(5),NH(2,3),IN,IH,IER
      REAL       Y(10),ALPHA,TEMP,HMUSIG(2,2),STAT(11)
      IN=2
      IH=2
      READ (from cards) (NBR(I),I=1,5),ALPHA
      N1=NBR(1)
      N2=NBR(2)
      READ (from cards) ((NH(I,J),I=1,N1),J=1,2)
      N=0
C                                  COMPUTE THE TOTAL NO. OF OBSERVATIONS
      DO 5 I=1,N1
        N=N+NH(I,1)
    5 CONTINUE
```

```
      IF (N2.NE.N) GO TO 10
      MM=1
      GO TO 20
   10 MM=0
      DO 15 I=1,N1
        NH(I,3)=(NH(I,1)+N2-1)/N2
        MM=MM+NH(I,3)
        IF (I.EQ.1) GO TO 15
        NH(I,3)=NH(I-1,3)+NH(I,3)
   15 CONTINUE
   20 L=1
      DO 30 M=1,MM
        NBR(3)=M
        NN=N2
        IF (MM.EQ.1) GO TO 25
        NS=NH(L,3)-1
        IF (M.NE.1 .AND. L.NE.1) NS=NH(L,3)-NH(L-1,3)-1
        IF (M.NE.NH(L,3)) GO TO 25
        NN=NH(L,1)-NS*NN
        L=L+1
   25   READ (from cards) (Y(J),J=1,NN)
        IF (NBR(4).EQ.0) READ (from card) TEMP
        CALL SSSBLK(Y,NBR,NH,IN,ALPHA,TEMP,HMUSIG,IH,STAT,IER)
   30 CONTINUE
      WRITE (on printer) ((HMUSIG(I,J),I=1,N1),J=1,2)
      WRITE (on printer) (STAT(I),I=1,11)
       .
       .
       .
      END
```

2. The notation used by Cochran (1963) for selected SSSBLK calling sequence parameters is given below.

SSSBLK Parameter	Union of all Y(=YY)	NBR(1)	NH(h,1)	NH(h,2)	HMUSIG(h,1)	HMUSIG(h,2)
Cochran's Notation	$\{y_{hi}\}$	L	n_h	N_h	$\bar{y}_h$	s_h^2

Example

Case 1:

Suppose it is desired to compute point and interval estimates of the population mean and total using a stratified random sample of size 25 from a population of size 64. Assume there are two strata and the corresponding strata sample and population sizes are (10,15) and (16, 48), respectively. For this case, in the example driver in Programming Notes above, NH(1,3)=1 and NH(2,3)=3. Thus 3 calls to SSSBLK are required to obtain the desired output.

1. CALL SSSBLK(Y,NBR,NH,IN,ALPHA,TEMP,HMUSIG,IH,STAT,IER)

Input: Y = (776.,800.,665.,1123.,575.,580.,483.,447.,452.,403.)
NBR = (2,10,1,0,1)

$$NH = \begin{bmatrix} 10 & 16 & - \\ 15 & 48 & - \end{bmatrix}$$

ALPHA= 0.10
TEMP = 600.

2. CALL SSSBLK(Y,NBR,NH,IN,ALPHA,TEMP,HMUSIG,IH,STAT,IER)

Input: Y = (186.,256.,263.,150.,167.,172.,173.,146.,314.,137.)
NBR = (2,10,2,0,1)

$$NH = \begin{bmatrix} 10 & 16 & - \\ 15 & 48 & - \end{bmatrix}$$

ALPHA= 0.10
TEMP = 175.

3. CALL SSSBLK(Y,NBR,NH,IN,ALPHA,TEMP,HMUSIG,IH,STAT,IER)

Input: Y = (193.,305.,100.,157.,201.)
NBR = (2,10,3,0,1)

$$NH = \begin{bmatrix} 10 & 16 & - \\ 15 & 48 & - \end{bmatrix}$$

ALPHA= 0.10
TEMP = 175.

Output:

$$HMUSIG = \begin{bmatrix} 630.40 & 48703. \\ 194.67 & 3913.0 \end{bmatrix}$$

STAT = (303.60,19430.,215.03,880753.,278.38,328.82,17816.,
21044.,4.8300,21.262,1226.0)
IER = 0

Case 2:

Usage of SSSBLK is simplified if the sample data is entered in its entirety and SSSBLK is called only once. This mode of usage is illustrated below for the same data as in Case 1.

Input: Y = (776.,800.,665.,1123.,575.,580.,483.,447.,452.,403.,
186.,256.,263.,150.,167.,172.,173.,146.,314.,137.,193.,
305.,100.,157.,201.)
NBR = (2,25,1,0,1)

$$NH = \begin{bmatrix} 10 & 16 & - \\ 15 & 48 & - \end{bmatrix}$$

ALPHA= 0.10
TEMP = 350.

Output:

Same as in Case 1.

IMSL ROUTINE NAME - SSSCAN

PURPOSE - SINGLE STAGE CLUSTER SAMPLING WITH CONTINUOUS DATA - INFERENCES REGARDING THE POPULATION MEAN AND TOTAL

USAGE - CALL SSSCAN (Y,IOPT,NBR,MC,IM,SIZE,TSIZE, ALPHA,TEMP,CMUSIG,IC,STAT,IER)

ARGUMENTS

Y - INPUT SUBVECTOR OF LENGTH NBR(2) OF THE VECTOR (CALL IT YY) CONTAINING THE ENTIRE CLUSTER SAMPLE. THE SUBVECTOR Y MUST BE EITHER THE SAME AS YY OR IT MUST CONTAIN ALL OR PART OF THE SAMPLE FOR A SINGLE CLUSTER ONLY. IN THE CASE WHERE Y IS A PROPER SUBSET OF YY, THE LAST SUBVECTOR FROM ANY ONE OR MORE OF THE CLUSTERS MAY HAVE FEWER THAN NBR(2) ELEMENTS. IN ALL CASES THE OBSERVATIONS WITHIN ANY ONE CLUSTER MUST APPEAR CONTIGUOUSLY IN YY.

IOPT - INPUT ESTIMATION OPTION.
IF IOPT IS NEGATIVE, UNBIASED ESTIMATION IS UTILIZED.
IF IOPT IS ZERO, RATIO TO SIZE ESTIMATION IS UTILIZED.
IF IOPT IS POSITIVE, PROBABILITY PROPORTIONAL TO SIZE ESTIMATION IS UTILIZED.

NBR - INPUT VECTOR OF LENGTH 7. NBR(I) CONTAINS, WHEN
I=1, NUMBER OF CLUSTERS INTO WHICH THE SAMPLE IS DIVIDED.
I=2, NUMBER OF OBSERVATIONS IN EACH SUBVECTOR Y, NOT INCLUDING THE LAST SUBVECTOR IN EACH CLUSTER, WHERE THE NUMBER MAY BE LESS THAN OR EQUAL TO NBR(2). HOWEVER, NBR(2) SHOULD BE THE SAME FOR ALL CALLS.
I=3, THE NUMBER OF THE SUBVECTOR STORED IN Y. SEE REMARKS.
I=4, THE TEMPORARY MEAN INDICATOR. IF NBR(4) = 0, THE USER SUPPLIES THE TEMPORARY MEAN IN TEMP. THE USER MAY CHANGE TEMP ONLY WHEN SUBVECTOR Y IS THE FIRST SET OF OBSERVATIONS IN A CLUSTER. IF NBR(4) DOES NOT EQUAL ZERO, THE FIRST ELEMENT IN EACH CLUSTER IS UTILIZED.
I=5, NUMBER OF CLUSTERS IN THE SAMPLED POPULATION.
I=6, NUMBER OF ELEMENTS IN THE POPULATION (SUM OF ALL THE CLUSTER SIZES IN THE POPULATION). NOT REQUIRED IF NBR(7) IS NONZERO.
I=7, OPTION FOR PROBABILITY PROPORTIONAL TO SIZE ESTIMATION. REQUIRED ONLY WHEN IOPT IS POSITIVE.

IF NBR(7) = 0, ALL CLUSTERS IN THE POPULATION ARE OF KNOWN SIZE.
IF NBR(7) IS NONZERO, THE CLUSTER SIZES ARE KNOWN ONLY APPROXIMATELY OR A MEASURE OF CLUSTER SIZE OTHER THAN THE NUMBER OF ELEMENTS PER CLUSTER IS TO BE USED.

MC - INPUT NBR(1) BY 2 MATRIX CONTAINING, IN COLUMN 1, THE NUMBER OF ELEMENTS IN EACH CLUSTER IN THE SAMPLE. THE SAMPLED CLUSTER SIZES MUST BE ORDERED IN CORRESPONDENCE WITH THE ORDERING OF CLUSTERS IN YY. COLUMN 2 IS WORK STORAGE.

IM - INPUT ROW DIMENSION OF MATRIX MC EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

SIZE - INPUT VECTOR OF LENGTH NBR(1), REQUIRED ONLY WHEN NBR(7) IS NONZERO, CONTAINING A MEASURE OF CLUSTER SIZE FOR EACH CLUSTER IN THE SAMPLE. THE SAMPLED CLUSTER SIZE MEASURES MUST BE ORDERED IN CORRESPONDENCE WITH THE ORDERING OF CLUSTERS IN YY.

TSIZE - INPUT MEASURE OF TOTAL SIZE OF ALL CLUSTERS IN THE POPULATION. REQUIRED ONLY WHEN NBR(7) IS NONZERO.

ALPHA - INPUT VALUE IN THE EXCLUSIVE INTERVAL (0,1) USED FOR COMPUTING 100(1-ALPHA) PERCENT CONFIDENCE INTERVALS FOR THE MEAN AND TOTAL PARAMETERS.

TEMP - INPUT TEMPORARY MEAN. REQUIRED ONLY IF NBR(4) = 0.

CMUSIG - OUTPUT NBR(1) BY 2 MATRIX CONTAINING THE WITHIN CLUSTER MEANS AND VARIANCES IN COLUMNS 1 AND 2, RESPECTIVELY. THE VALUES ARE ORDERED IN CORRESPONDENCE WITH THE ORDERING OF CLUSTERS IN YY.

IC - INPUT ROW DIMENSION OF MATRIX CMUSIG EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

STAT - OUTPUT VECTOR OF LENGTH 9. STAT(I) CONTAINS, WHEN
I=1, ESTIMATE OF THE MEAN.
I=2, ESTIMATE OF THE TOTAL.
I=3, VARIANCE ESTIMATE OF THE MEAN ESTIMATE.
I=4, VARIANCE ESTIMATE OF THE TOTAL ESTIMATE
I=5, LOWER CONFIDENCE LIMIT FOR THE MEAN.
I=6, UPPER CONFIDENCE LIMIT FOR THE MEAN.
I=7, LOWER CONFIDENCE LIMIT FOR THE TOTAL.
I=8, UPPER CONFIDENCE LIMIT FOR THE TOTAL.
I=9, ESTIMATE (EXPRESSED AS A PERCENTAGE) OF THE COEFFICIENT OF VARIATION OF THE MEAN AND TOTAL ESTIMATES.

IER - ERROR PARAMETER. (OUTPUT)
TERMINAL ERROR
IER = 129 INDICATES NBR(1) IS LESS THAN 2 OR THAT NBR(2) IS LESS THAN 1.
IER = 130 INDICATES NBR(3) IS LESS THAN 1 OR THAT NBR(2)*(NBR(3)-NBR(1)) EXCEEDS THE

NUMBER (TOTAL OF COLUMN 1 OF MC) OF ELEMENTS IN YY.

IER = 131 INDICATES THAT AT LEAST ONE ELEMENT OF COLUMN 1 OF MC IS LESS THAN 1 OR THAT ALPHA IS NOT IN THE EXCLUSIVE INTERVAL (0,1).

IER = 132 INDICATES THAT NBR(2) IS GREATER THAN SOME MC(I,1),I=1,...,NBR(1) WHEN NBR(2) IS LESS THAN THE TOTAL SAMPLE SIZE, OR THAT NBR(2) EXCEEDS THE TOTAL SAMPLE SIZE.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - MDNRIS,MERFI,UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS BETWEEN THE FIRST AND LAST CALL TO SSSCAN, EXCEPT FOR OPTIONALLY CHANGING TEMP BETWEEN CLUSTERS, ONLY NBR(3) MAY BE MODIFIED AND IT SHOULD FOLLOW THE PATTERN 1,2,... . THOUGH THIS PATTERN IS THE OBVIOUS ONE TO FOLLOW, IT IS NOT NECESSARY IN ITS ENTIRETY. FOR THE FIRST AND LAST SUBVECTOR WITHIN EACH CLUSTER, NBR(3) MUST HAVE ITS CORRECT PATTERN VALUE. FOR THE INTERMEDIATE SUBVECTORS WITHIN EACH STRATUM, NBR(3) MAY TAKE ANY VALUE BETWEEN THE CORRESPONDING FIRST AND LAST SUBVECTOR NBR(3) VALUES.

Algorithm

Let n=NBR(1), M_i=MC(i,1), $R=\sum_{i=1}^{n} M_i$, r_i=greatest integer in (M_i+NBR(2)-1)/NBR(2), and $r=\sum_{i=1}^{n} r_i$. Then, given a vector (call it YY) of length R containing the cluster sample, SSSCAN computes point and interval estimates for the population mean and total. On option, unbiased, ratio to size, or probability proportional to size estimation is utilized. Only a subvector, Y, of YY is available to the routine at any one time and the results are available only after SSSCAN has been called for the r-th time. (If NBR(2)=R, r=1.) Y is comprised of a set of elements of YY such that Y never includes elements from more than one stratum (unless NBR(2)=R), which are presented, in order, to Y through the call.

Let y_{ij} be the j-th observation in cluster i in subvector Y, where Y is a subvector of YY, for j=1,2,...,M_i; i=1,2,...,n.

Let T_i=TEMP for cluster i and let $t_{ij}=y_{ij}-T_i$, for j and i as in the definition of y_{ij}, above. Then

$$\bar{y}_i = \text{CMUSIG}(i,1) = \sum_{j=1}^{M_i} y_{ij}/M_i$$

$$M_i s_i^2 = (M_i)\text{CMUSIG}(i,2) = \sum_{j=1}^{M_i} t_{ij}^2 - M_i(\bar{y}_i - T_i)^2$$

In general, more than one subvector Y will contain observations in a single cluster, and thus, in the code, the summations above are also over multiple subvectors.

The remaining computations depend on the above and are described in Chapter 9 of the reference below.

SSSCAN is designed so that a user with a large data vector (YY) and/or limited core may partition that vector into subvectors, and make multiple calls to SSSCAN, subject to the restriction that no subvector may contain data from more than one cluster. Alternatively, where core availability is no problem, the user may enter SSSCAN with YY (equal to Y in this case) in its entirety and call SSSCAN only once.

See reference:

Cochran, W. G., Sampling Techniques, John Wiley and Sons, New York, 1963, Chapter 9.

Programming Notes

1. A common usage of SSSCAN's core conserving characteristics would be to write the data vector YY onto disk or tape and then alternately read subvectors, Y, and call SSSCAN. For example, a driver for SSSCAN could be written as follows for the example given in the Example section below. Case 1 illustrates a situation in which YY is partitioned into three subvectors. Dimensioning in the listing below is set for Case 1. Obvious changes are needed for Case 2.

```
      INTEGER         IOPT,NBR(7),MC(2,2),IM,IC,IER
      REAL            Y(4),SIZE(2),TSIZE,ALPHA,TEMP,CMUSIG(2,2),STAT(9)
      IM = 2
      IC = 2
      READ (from cards) (NBR(I),I=1,7),IOPT,ALPHA
      N1 = NBR(1)
      N2 = NBR(2)
      READ (from cards) (MC(I,1),I=1,N1)
      IF (NBR(7) .NE. 0) READ (from cards) (SIZE(I),I=1,N1),TSIZE
      N = 0
      DO 5 I=1,N1
         N = N+MC(I,1)
    5 CONTINUE
      IF (N2 .NE. N) GO TO 10
      MM = 1
      GO TO 20
   10 MM = 0
      DO 15 I=1,N1
         MC(I,2) = (MC(I,1)+N2-1)/N2
         MM = MM+MC(I,2)
         IF (I .EQ. 1) GO TO 15
         MC(I,2) = MC(I-1,2)+MC(I,2)
```

```
15 CONTINUE
20 L = 1
   DO 30 M=1,MM
      NBR(3) = M
      NN = N2
      IF (MM .EQ. 1) GO TO 25
      NS = MC(L,2)-1
      IF (M .NE. 1 .AND. L .NE. 1) NS = MC(L,2)-MC(L-1,2)-1
      IF (M .NE. MC(L,2)) GO TO 25
      NN = MC(L,1)-NS*NN
      L = L+1
25    READ (from cards) (Y(J),J=1,NN)
      IF (NBR(4) .EQ. 0) READ (from card) TEMP
      CALL SSSCAN(Y,IOPT,NBR,MC,IM,SIZE,TSIZE,ALPHA,TEMP,CMUSIG,IC,
  *   STAT,IER)
30 CONTINUE
   WRITE (on printer) (CMUSIG(I,J),I=1,N1),J=1,2)
   WRITE (on printer) ((STAT(I),I=1,9)
    .
    .
    .
   END
```

2. The notation used by Cochran (1963) for selected SSSCAN calling sequence parameters is given below.

SSSCAN Parameter	Union of all Y(=YY)	NBR(1)	NBR(5)	NBR(6)	MC(i,1)	TSIZE	SIZE(i)
Cochran's Notation	$\{y_{ij}\}$	n	N	M_o	M_i	M'_o	M'_i

Example

Case 1:

Suppose it is desired to compute point and interval estimates of the population mean and total using a single stage cluster sample consisting of two clusters from a population of twenty clusters. Assume the sampled cluster sizes are four and six, respectively, and that there are a total of 100 elements in the population. For this case, in the example driver in Programming Notes above, MC(1,2)=1, and MC(2,2)=3. Thus three calls to SSSCAN are required to obtain the desired output.

1. CALL SSSCAN(Y,IOPT,NBR,MC,IM,SIZE,TSIZE,ALPHA,TEMP,CMUSIG, IC,STAT,IER)

Input:

Y = (2.7,5.1,4.3,2.8)

IOPT = 0

NBR = (2,4,1,0,20,100,-)

$$MC = \begin{bmatrix} 4 & - \\ 6 & - \end{bmatrix}$$

```
SIZE undefined
TSIZE undefined
ALPHA=    0.10
TEMP =    4.0
```

2. CALL SSSCAN(Y,IOPT,NBR,MC,IM,SIZE,TSIZE,ALPHA,TEMP,CMUSIG, IC,STAT,IER)

Input: (same as first call except as indicated below)

```
Y      =   (1.9,6.2,4.8,5.1)
NBR(3)=    2
TEMP   =   6.0
```

3. CALL SSSCAN(Y,IOPT,NBR,MC,IM,SIZE,TSIZE,ALPHA,TEMP,CMUSIG, IC,STAT,IER)

Input: (same as first call except as indicated below)

```
Y      =   (7.2,6.5)
NBR(3)=    3
TEMP   =   6.0
```

Output:

```
CMUSIG=  [3.7250   1.0319]
         [5.2833   2.9514]

STAT   =   (4.6600,466.00,0.50355,5035.5,3.4928,
            5.8272,349.28,582.72,15.228)
IER    =   0
```

Case 2:

Usage of SSSCAN is simplified if the sample data is entered in its entirety and SSSCAN is called only once. This mode of usage is illustrated below for the same data as in Case 1.

Input:

```
Y      =   (2.7,5.1,4.3,2.8,1.9,6.2,4.8,5.1,7.2,6.5)
IOPT   =   0
NBR    =   (2,10,1,0,20,100,-)

MC     =  [4   -]
          [6   -]

SIZE undefined
TSIZE undefined
ALPHA=    0.10
TEMP =    5.0
```

Output: Same as in Case 1.

IMSL ROUTINE NAME - SSSEST

PURPOSE - TWO-STAGE SAMPLING WITH CONTINUOUS DATA AND EQUISIZED PRIMARY UNITS - INFERENCES REGARDING THE POPULATION MEAN AND TOTAL

USAGE - CALL SSSEST(Y,NBR,ALPHA,TEMP,SMUSIG,IS,STAT, IER)

ARGUMENTS

Y - INPUT SUBVECTOR OF LENGTH NBR(2) OF THE VECTOR (CALL IT YY) CONTAINING THE ENTIRE TWO-STAGE SAMPLE. THE SUBVECTOR Y MUST BE EITHER THE SAME AS YY OR IT MUST CONTAIN ALL OR PART OF THE SAMPLE FOR A SINGLE PRIMARY UNIT ONLY. IN THE CASE WHERE Y IS A PROPER SUBSET OF YY, THE LAST SUBVECTOR FROM ANY ONE OR MORE OF THE PRIMARY UNITS MAY HAVE FEWER THAN NBR(2) ELEMENTS. IN ALL CASES THE OBSERVATIONS WITHIN ANY ONE PRIMARY UNIT MUST APPEAR CONTIGUOUSLY IN YY.

NBR - INPUT VECTOR OF LENGTH 7. NBR(I) CONTAINS, WHEN,
- I=1, NUMBER OF PRIMARY UNITS INTO WHICH THE SAMPLE IS DIVIDED.
- I=2, NUMBER OF OBSERVATIONS IN EACH SUBVECTOR Y, NOT INCLUDING THE LAST SUBVECTOR IN EACH PRIMARY UNIT, WHERE THE NUMBER MAY BE LESS THAN OR EQUAL TO NBR(2). HOWEVER, NBR(2) SHOULD BE THE SAME FOR ALL CALLS.
- I=3, THE NUMBER OF THE SUBVECTOR STORED IN Y. SEE REMARKS.
- I=4, TEMPORARY MEAN INDICATOR. IF NBR(4)=0, THE USER SUPPLIES THE TEMPORARY MEAN IN TEMP. THE USER MAY CHANGE TEMP ONLY WHEN SUBVECTOR Y IS THE FIRST SET OF OBSERVATIONS IN A PRIMARY UNIT. IF NBR(4) IS NON-ZERO, THE FIRST ELEMENT OF EACH PRIMARY UNIT IS UTILIZED.
- I=5, NUMBER OF PRIMARY UNITS IN THE SAMPLED POPULATION.
- I=6, NUMBER OF ELEMENTS IN EACH PRIMARY UNIT IN THE POPULATION.
- I=7, NUMBER OF ELEMENTS IN THE SAMPLE IN EACH SAMPLED PRIMARY UNIT.

ALPHA - INPUT VALUE IN THE EXCLUSIVE INTERVAL (0,1) USED FOR COMPUTING 100(1-ALPHA) PERCENT CONFIDENCE INTERVALS FOR THE MEAN AND TOTAL PARAMETERS.

TEMP - INPUT TEMPORARY MEAN. REQUIRED ONLY IF NBR(4)=0.

SMUSIG - OUTPUT NBR(1) BY 2 MATRIX CONTAINING THE WITHIN PRIMARY UNIT MEAN AND VARIANCE ESTIMATES IN COLUMNS 1 AND 2, RESPECTIVELY. THE ESTIMATES ARE ORDERED IN CORRESPONDENCE WITH THE ORDERING OF PRIMARY UNITS IN YY.

IS - INPUT ROW DIMENSION OF MATRIX SMUSIG EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM.

STAT - OUTPUT VECTOR OF LENGTH 9. STAT(I) CONTAINS, WHEN
I=1, ESTIMATE OF THE MEAN.
I=2, ESTIMATE OF THE TOTAL.
I=3, VARIANCE ESTIMATE OF THE MEAN ESTIMATE.
I=4, VARIANCE ESTIMATE OF THE TOTAL ESTIMATE.
I=5, LOWER CONFIDENCE LIMIT FOR THE MEAN.
I=6, UPPER CONFIDENCE LIMIT FOR THE MEAN.
I=7, LOWER CONFIDENCE LIMIT FOR THE TOTAL.
I=8, UPPER CONFIDENCE LIMIT FOR THE TOTAL.
I=9, ESTIMATE (EXPRESSED AS A PERCENTAGE) OF THE COEFFICIENT OF VARIATION OF THE MEAN AND TOTAL ESTIMATES.

IER - ERROR PARAMETER. (OUTPUT)
TERMINAL ERROR
IER = 129 INDICATES NBR(1) IS LESS THAN 2 OR THAT NBR(2) IS LESS THAN 1.
IER = 130 INDICATES NBR(3) IS LESS THAN 1 OR THAT NBR(2)*(NBR(3)-NBR(1)) EXCEEDS THE NUMBER (NBR(1)*NBR(7)) OF ELEMENTS IN YY.
IER = 131 INDICATES THAT NBR(1) EXCEEDS NBR(5) OR THAT ALPHA IS NOT IN THE EXCLUSIVE INTERVAL (0,1).
IER = 132 INDICATES THAT NBR(7) IS LESS THAN 2 OR THAT NBR(7) EXCEEDS NBR(6).
IER = 133 INDICATES THAT NBR(2) EXCEEDS NBR(1)*NBR(7).

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - MDNRIS,MERFI,UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS BETWEEN THE FIRST AND LAST CALL TO SSSEST, EXCEPT FOR OPTIONALLY CHANGING TEMP BETWEEN PRIMARY UNITS, ONLY NBR(3) MAY BE MODIFIED AND IT SHOULD FOLLOW THE PATTERN 1,2,... . THOUGH THIS PATTERN IS THE OBVIOUS ONE TO FOLLOW, IT IS NOT NECESSARY IN ITS ENTIRETY. FOR THE FIRST AND LAST SUBVECTOR WITHIN EACH PRIMARY UNIT, NBR(3) MUST HAVE ITS CORRECT PATTERN VALUE. FOR THE INTERMEDIATE SUBVECTORS WITHIN EACH PRIMARY UNIT, NBR(3) MAY TAKE ANY VALUE BETWEEN THE CORRESPONDING FIRST AND LAST SUBVECTOR NBR(3) VALUES.

Algorithm

Let n=NBR(1), m=NBR(7), R=nm, r=greatest integer in (m+NBR(2)-1)/NBR(2). Then, given a vector (call it YY) of length R containing the two-stage sample, SSSEST computes point and interval estimates for the population mean and total. Only a subvector, Y, of YY is

available to the routine at any one time and the results are available only after SSSEST is called for the nr-th time. (If NBR(2)=R, nr=1.) Y is comprised of a set of elements of YY such that Y never includes elements from more than one primary unit (unless NBR(2)=R), which are presented, in order, to Y through the call.

Let y_{ij} be the j-th observation in primary unit i in subvector Y, where Y is a subvector of YY, for j=1,2,...,m; i=1,2,...,n.

Let T_i=TEMP for primary unit i and let $t_{ij}=y_{ij}-T_i$, for j and i as in the definition of y_{ij} above.

Then

$$\bar{y}_i = \text{SMUSIG}(i,1) = \sum_{j=1}^{m} y_{ij}/m$$

$$(m-1)s_i^2 = \text{SMUSIG}(i,2) = \sum_{j=1}^{m} t_{ij}^2 - m(\bar{y}_i - T_i)^2$$

In general, more than one subvector Y will contain observations in a single primary unit, and thus, in the code, the summations above are also over multiple subvectors.

The remaining computations depend on the above and are described in Chapter 10 of the reference below.

SSSEST is designed so that a user with a large data vector (YY) and/or limited core may partition that vector into subvectors, and make multiple calls to SSSEST, subject to the restriction that no subvector may contain data from more than one primary unit. Alternatively, when core availability is no problem, the user may enter SSSEST with YY (equal to Y in this case) in its entirety and call SSSEST only once.

See reference:

Cochran, W. G., Sampling Techniques, John Wiley and Sons, New York, 1963, Chapter 10.

Programming Notes

1. A common usage of SSSEST's core conserving characteristics would be to write the data vector YY onto disk or tape and then alternately read subvectors, Y, and call SSSEST. For example, a driver for SSSEST could be written as follows for the example given in the Example section below. Case 1 illustrates a situation in which YY is partitioned into two subvectors. Dimensioning in the listing below is set for Case 1. Obvious changes are needed for Case 2.

```
      INTEGER              NBR(7),IS,IER
      REAL                 Y(5),ALPHA,TEMP,SMUSIG(2,2),STAT(9)
      READ (from cards) (NBR(I),I=1,7)
      READ (from cards) ALPHA
      IS=2
      NBR1=NBR(1)
      IEND=NBR(1)
      NBR2=NBR(2)
      IF(NBR(2) .EQ. NBR(1)*NBR(7)) IEND=1
      L=1
      IF(NBR(2) .NE. 0) L=((NBR(7)+NBR(2)-1)/NBR(2))
      K=1
      DO 10 I=1,IEND
         DO 5 JJ=1,L
            JEND=NBR(2)
            IF(J .EQ. L) JEND=NBR(7)-(L-1)*NBR(2)
            IF(NBR(2) .EQ. NBR(1)*NBR(7)) JEND=NBR(2)
            READ (from cards) (Y(J),J=1,JEND)
            IF(NBR(4) .EQ. 0) READ (from cards) TEMP
            NBR(3)=K
            CALL SSSEST(Y,NBR,ALPHA,TEMP,SMUSIG,IS,STAT,IER)
            K=K+1
    5    CONTINUE
   10 CONTINUE
      WRITE (on printer) ((SMUSIG(I,J),I=1,NBR2),J=1,2)
      WRITE (on printer) (STAT(J),J=1,9)
       .
       .
       .
      END
```

2. The notation used by Cochran (1963) for selected SSSEST calling sequence parameters is given below.

SSSEST Parameter	Union of all Y(=YY)	NBR(1)	NBR(5)	NBR(6)	NBR(7)
Cochran's Notation	$\{y_{ij}\}$	n	N	M	m

Example

Case 1:

Suppose it is desired to compute point and interval estimates of the population mean and total using a two-stage sample of size 10 from a population of 150 elements. The 150 elements consist of 10 primary units of 15 elements each. The sample consists of 2 primary units with 5 elements taken from each. For this case, in the example driver in Programming Notes above, NBR1=2 and L=1. Thus (2)(1)=2 calls to SSSEST are required to obtain the desired output.

1. CALL SSSEST(Y,NBR,ALPHA,TEMP,SMUSIG,IS,STAT,IER)

Input:
```
Y     =    (2.7,5.1,4.3,2.8,1.9)
NBR   =    (2,5,1,0,10,15,5)
ALPHA=     0.05
TEMP  =    4.0
```

2. CALL SSSEST(Y,NBR,ALPHA,TEMP,SMUSIG,IS,STAT,IER)

Input:
```
Y     =    (6.2,4.8,5.1,7.2,6.5)
NBR   =    (2,5,2,0,10,15,5)
ALPHA=     0.05
TEMP  =    6.0
```

Output:

$$SMUSIG = \begin{bmatrix} 3.3600 & 1.6980 \\ 5.9600 & 0.99300 \end{bmatrix}$$

```
STAT  =    (4.6600,699.00,1.3699,30824.,2.3660,
            6.9540,354.90,1043.1,25.117)
IER   =    0
```

Case 2:

Usage of SSSEST is simplified if the sample data is entered in its entirety and SSSEST is called only once. This mode of usage is illustrated below for the same data as in Case 1.

Input:
```
Y     =    (2.7,5.1,4.3,2.8,1.9,6.2,4.8,5.1,7.2,6.5)
NBR   =    (2,10,1,0,10,15,5)
ALPHA=     0.05
TEMP  =    5.0
```

Output: Same as in Case 1.

UTILITY FUNCTIONS

This chapter contains abilities intended to aid the user in four areas.

1. Selection of specific I/O units for input and output routines.
2. Printing of detected errors, as handled by UERTST.
3. Certain input/output abilities are included which handle standard problems and certain special problems (such as printing a matrix stored in symmetric mode).
4. Obtaining "help" information.
5. Printer graphics useful in statistical data analysis.

Please note: Certain routines in this chapter have arguments that provide character strings. These should be of the form 'string' for some compilers and of the form nHstring for others. See Section 5.3 of the INTRODUCTION for a list showing which form should be used for each supported compiler.

Quick Reference Guide to Chapter Abilities

Error Information and I/O Unit Selection

- UERSET - set message level for UERTST
- UERTST - print a message reflecting an error condition
- UGETIO - retrieve current values and set new values for input and output unit identifiers

Special I/O

- USBOX - print a box plot (K samples)
- USHHST - print a histogram (horizontal)
- USHST - print a histogram (vertical)
- USHST2 - print a histogram, plotting two frequencies with one bar of the histogram (vertical)
- USLEAP - print results of the best-regressions analysis performed by IMSL routine RLEAP
- USMNMX - determination of the minimum and maximum values of a vector.
- USPC - print a sample CDF, a theoretical CDF and confidence band information
- USPDF - plot of two sample cumulative probability distribution functions against their spectra
- USPLO - printer plot of up to ten functions
- USPLOD - printer plot of up to ten functions (double precision version)
- USPRP - probability plot
- USSLF - print a stem and leaf display
- USTREE - print a binary tree (which may represent the result of a clustering algorithm in Chapter O)
- USWBM - print a matrix stored in band storage mode
- USWBS - print a matrix stored in band symmetric storage mode
- USWCH - print a complex Hermitian matrix stored in Hermitian storage mode.
- USWCM - print a complex matrix stored in full storage mode
- USWCV - print a complex vector

USWFM - print a matrix stored in full storage mode
USWFV - print a vector
USWSM - print a matrix stored in symmetric storage mode

Help Routines
UHELP - display general information about help routines
UHELP1 - write information regarding IMSL conventions and notation
UHELP2 - write information regarding IMSL input and output conventions
UHELP3 - write information regarding IMSL error detecting facilities
UHELP4 - write information regarding matrix/vector storage modes

Featured Abilities

IMSL features its "symmetric" and "band" input/output routines. For example, allow the user to use storage saving symmetric or band matrix abilities and print those matrices in a readable form.

UERTST, the error information routine, is especially important. If the user elects to ignore IER, the error parameter at the end of most argument lists, a clear message will be printed if the routine detects an error. If the user wishes to eliminate the printed messages, the routine UERSET may be called.

Subroutines that produce graphic output useful in statistical data analysis include the following:

Histograms and similar plots	-	USHST,USHST2,USHHST,USSLF
Bivariate plots	-	USPLO,USPLOD
Plots for comparing sample distributions with hypothesized distributions	-	USPC,USPDF,USPRP
Plots for comparing two or more samples	-	USBOX,USHST2

Name Conventions for This Chapter

All subroutine names begin with the letter U.

UE implies error detecting information routines.
UG implies input/output unit selection routines.
UH implies help routines.
US implies special input/output routines.

IMSL ROUTINE NAME - UERSET

PURPOSE - SET MESSAGE LEVEL FOR IMSL ROUTINE UERTST

USAGE - CALL UERSET (LEVEL,LEVOLD)

ARGUMENTS LEVEL - NEW VALUE FOR MESSAGE LEVEL. (INPUT)
OUTPUT FROM IMSL ROUTINE UERTST IS
CONTROLLED SELECTIVELY AS FOLLOWS,
LEVEL = 4 CAUSES ALL MESSAGES TO BE PRINTED,
LEVEL = 3 MESSAGES ARE PRINTED IF IER IS GREATER THAN 32,
LEVEL = 2 MESSAGES ARE PRINTED IF IER IS GREATER THAN 64,
LEVEL = 1 MESSAGES ARE PRINTED IF IER IS GREATER THAN 128,
LEVEL = 0 ALL MESSAGE PRINTING IS SUPPRESSED.
LEVOLD - PREVIOUS MESSAGE LEVEL. (OUTPUT)

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

Algorithm

IMSL routine UERTST retains the message level in a local variable. UERSET can reset the message level to any value between 0 and 4 and retrieve the current value.

Example

Eliminate the printing of all except terminal (IER>128) error messages.

Input:

```
LEVEL = 1
CALL UERSET (LEVEL,LEVOLD)
```

Output:

The local error message level retained by UERTST is reset to 1 and LEVOLD is set to the previous message level.

IMSL ROUTINE NAME - UERTST

PURPOSE - PRINT A MESSAGE REFLECTING AN ERROR CONDITION

USAGE - CALL UERTST (IER,NAME)

ARGUMENTS IER - ERROR PARAMETER. (INPUT)
IER = I+J WHERE
I = 128 IMPLIES TERMINAL ERROR MESSAGE,
I = 64 IMPLIES WARNING WITH FIX MESSAGE,
I = 32 IMPLIES WARNING MESSAGE.
J = ERROR CODE RELEVANT TO CALLING ROUTINE.

NAME - A SIX CHARACTER LITERAL STRING GIVING THE NAME OF THE CALLING ROUTINE. (INPUT)

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS THE ERROR MESSAGE PRODUCED BY UERTST IS WRITTEN TO THE STANDARD OUTPUT UNIT. THE OUTPUT UNIT NUMBER CAN BE DETERMINED BY CALLING UGETIO AS FOLLOWS.. CALL UGETIO(1,NIN,NOUT).
THE OUTPUT UNIT NUMBER CAN BE CHANGED BY CALLING UGETIO AS FOLLOWS..

```
NIN = 0
NOUT = NEW OUTPUT UNIT NUMBER
CALL UGETIO(3,NIN,NOUT)
```

SEE THE UGETIO DOCUMENT FOR MORE DETAILS.

Algorithm

The error indicator, IER, passed to UERTST is analyzed and an appropriate error message is printed in the following format:

***error message (IER=n) FROM IMSL ROUTINE name

where n=the value of IER and name is the six character literal string giving the name of the calling routine. The following table gives the error message corresponding to IER.

IER	Error Message
$IER \leq 32$	UNDEFINED ERROR
$32 < IER \leq 64$	WARNING ERROR
$64 < IER \leq 128$	WARNING WITH FIX ERROR
$128 < IER$	TERMINAL ERROR

UERSET can be called to selectively eliminate printing certain error messages and UGETIO can be used to change the output unit used for printing the message.

Example

Print a warning error with IER=33 and name=ABC.

Input:

```
IER = 33
   CALL UERTST (IER,6HABC   )        { HOLLERITH form
or CALL UERTST (IER,'ABC   ')        { CHARACTER form
                                     { See INTRO Section 5.3 for details
```

Output:

```
*** WARNING ERROR              (IER=33) FROM IMSL ROUTINE ABC
```

IMSL ROUTINE NAME - UGETIO

PURPOSE - TO RETRIEVE CURRENT VALUES AND TO SET NEW VALUES FOR INPUT AND OUTPUT UNIT IDENTIFIERS

USAGE - CALL UGETIO(IOPT,NIN,NOUT)

ARGUMENTS

IOPT - OPTION PARAMETER. (INPUT)
IF IOPT=1, THE CURRENT INPUT AND OUTPUT UNIT IDENTIFIER VALUES ARE RETURNED IN NIN AND NOUT, RESPECTIVELY.
IF IOPT=2, THE INTERNAL VALUE OF NIN IS RESET FOR SUBSEQUENT USE.
IF IOPT=3, THE INTERNAL VALUE OF NOUT IS RESET FOR SUBSEQUENT USE.

NIN - INPUT UNIT IDENTIFIER.
OUTPUT IF IOPT=1, INPUT IF IOPT=2.

NOUT - OUTPUT UNIT IDENTIFIER.
OUTPUT IF IOPT=1, INPUT IF IOPT=3.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - NONE REQUIRED

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS EACH IMSL ROUTINE THAT PERFORMS INPUT AND/OR OUTPUT OPERATIONS CALLS UGETIO TO OBTAIN THE CURRENT UNIT IDENTIFIER VALUES. IF UGETIO IS CALLED WITH IOPT=2 OR IOPT=3, NEW UNIT IDENTIFIER VALUES ARE ESTABLISHED. SUBSEQUENT INPUT/OUTPUT IS PERFORMED ON THE NEW UNITS.

Algorithm

Input and output unit identifier values are stored in local variables NIND and NOUTD, respectively. When IOPT=1 the current values are returned in arguments NIN and NOUT. When IOPT=2, NIND is reset to the value of argument NIN. When IOPT=3, NOUTD is reset to the value of argument NOUT. NIND and NOUTD are initialized in a DATA statement in subroutine UGETIO. Default: NIND=5 NOUTD=5

Example

Reset the output unit to 10. All subsequent output from IMSL routines (e.g., error messages from UERTST) will be written to unit 10.

Input:

```
NIN  = 0
NOUT = 10
IOPT = 3
CALL UGETIO (IOPT,NIN,NOUT)
```

Output:

On subsequent calls to UGETIO with IOPT=1, NOUT will be set to 10. All output from IMSL routines will be written to unit 10.

IMSL ROUTINE NAME - UHELP

PURPOSE - DISPLAY METHODS OF OBTAINING INFORMATION ON IMSL CONVENTIONS REGARDING VARIOUS SUBJECTS AND PROVIDE A MEANS FOR INDIVIDUAL SITES TO SUPPLY USERS WITH SITE SPECIFIC INFORMATION

USAGE - CALL UHELP

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS IF THE USER DESIRES THAT OUTPUT BE WRITTEN TO A DEVICE OTHER THAN THE STANDARD OUTPUT DEVICE, HE MUST FIRST CALL IMSL ROUTINE UGETIO TO RESET THE OUTPUT DEVICE. SEE THE UGETIO DOCUMENT.

Algorithm

Routine UHELP first calls IMSL routine UGETIO to set the output device. Installations may wish to use UHELP to supply users with other information concerning their installation. This can be achieved by adding the desired WRITE statements within routine UHELP.

Example

To display on the standard output device information on IMSL conventions regarding various subjects one would run the following program:

Input:

```
CALL UHELP
STOP
END
```

Output:

Detailed information concerning IMSL conventions on the following subjects is available by calling the indicated IMSL routine:

Subject	Routine
Documentation conventions and notation	CALL UHELP1
Input/output conventions	CALL UHELP2
Error detecting facilities	CALL UHELP3
Matrix/vector storage mode	CALL UHELP4

For example, to obtain information regarding IMSL input and output conventions, one would run the following program:

```
CALL UHELP2
STOP
END
```

IMSL ROUTINE NAME - UHELP1

PURPOSE - WRITE INFORMATION REGARDING IMSL CONVENTIONS AND NOTATION TO AN OUTPUT FILE

USAGE - CALL UHELP1

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS IF THE USER DESIRES THAT OUTPUT BE WRITTEN TO A DEVICE OTHER THAN THE STANDARD OUTPUT DEVICE, HE MUST FIRST CALL IMSL ROUTINE UGETIO TO RESET THE OUTPUT DEVICE. SEE THE UGETIO DOCUMENT.

Algorithm

Routine UHELP1 first calls IMSL routine UGETIO to set the output device. UHELP1 then writes to the output device.

Example

To write information regarding IMSL conventions and notation to the standard output file, one would run the following program:

Input:

```
CALL UHELP1
STOP
END
```

Output:

(Sections of the IMSL manual introduction are printed on output.)

IMSL ROUTINE NAME - UHELP2

PURPOSE - WRITE INFORMATION REGARDING IMSL INPUT AND OUTPUT CONVENTIONS

USAGE - CALL UHELP2

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS IF THE USER DESIRES THAT OUTPUT BE WRITTEN TO A DEVICE OTHER THAN THE STANDARD OUTPUT DEVICE, HE MUST FIRST CALL IMSL ROUTINE UGETIO TO RESET THE OUTPUT DEVICE. SEE THE UGETIO DOCUMENT.

Algorithm

Routine UHELP2 first calls IMSL routine UGETIO to set the output device. UHELP then writes to the output device.

Example

To write information regarding IMSL input and output conventions to the standard output device, one would run the following program.

Input:

```
CALL UHELP2
STOP
END
```

Output:

Input/output conventions

All IMSL routines, except some of those in Chapter U, are input/output free. Each of the Chapter U routines that performs input and/or output operations calls subroutine UGETIO to obtain the current unit identifier values. UGETIO may be called by the user to set new values for unit identifiers and this causes all subsequent input/output by other IMSL routines to be performed on the new units. Details are given in the UGETIO document.

IMSL ROUTINE NAME - UHELP3

PURPOSE - WRITE INFORMATION REGARDING IMSL ERROR DETECTING FACILITIES

USAGE - CALL UHELP3

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS IF THE USER DESIRES THAT OUTPUT BE WRITTEN TO A DEVICE OTHER THAN THE STANDARD OUTPUT DEVICE, HE MUST FIRST CALL IMSL ROUTINE UGETIO TO SET THE OUTPUT DEVICE. SEE THE UGETIO DOCUMENT.

Algorithm

Routine UHELP3 first calls IMSL routine UGETIO to set the output device. UHELP3 then writes to the output device.

Example

To write information regarding IMSL error detecting facilities to the standard output file, one would run the following program:

Input:

```
CALL UHELP3
STOP
END
```

Output:

(Sections of the IMSL manual introduction are printed on output.)

IMSL ROUTINE NAME - UHELP4

PURPOSE - WRITE INFORMATION REGARDING MATRIX/VECTOR STORAGE MODES USED IN IMSL SUBROUTINES

USAGE - CALL UHELP4

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS IF THE USER DESIRES THAT OUTPUT BE WRITTEN TO A DEVICE OTHER THAN THE STANDARD OUTPUT DEVICE, HE MUST FIRST CALL IMSL ROUTINE UGETIO TO RESET THE OUTPUT DEVICE. SEE THE UGETIO DOCUMENT.

Algorithm

Routine UHELP4 first calls IMSL routine UGETIO to set the output device. UHELP4 then writes to the output device.

Example

To write information regarding matrix/vector storage modes used in IMSL routines to the standard output file, one would run the following program:

Input:

```
CALL UHELP4
STOP
END
```

Output:

(Sections of the IMSL manual introduction are printed on output.)

IMSL ROUTINE NAME - USBOX

PURPOSE - PRINT A BOXPLOT (K SAMPLES)

USAGE - CALL USBOX (X,K,NI,MAXL,IER)

ARGUMENTS

X - INPUT VECTOR OF LENGTH NI(1)+NI(2)+...+NI(K) CONTAINING IN THE FIRST NI(1) POSITIONS THE OBSERVATIONS FOR THE FIRST SAMPLE IN THE NEXT NI(2) POSITIONS, THE OBSERVATIONS FOR THE SECOND SAMPLE AND SO ON. ON OUTPUT, EACH SAMPLE WILL BE SORTED.

K - THE NUMBER OF SAMPLES. (INPUT)

NI - VECTOR OF LENGTH K. (INPUT) NI(I) IS THE NUMBER OF OBSERVATIONS IN THE I-TH SAMPLE.

MAXL - MAXIMUM DISPLAY WIDTH. (INPUT) MAXL MUST BE 80 OR 129.

IER - ERROR PARAMETER (OUTPUT)
WARNING ERROR WITH FIX
IER=65 INDICATES MAXL DID NOT EQUAL 80 OR 129. MAXL IS SET TO 80.
TERMINAL ERROR
IER=129 INDICATES NI(I) IS LESS THAN 1.
IER=130 INDICATES K IS LESS THAN 1.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - BDLTV,UERTST,USBOX1,UGETIO,VSRTA

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS IF XMAT IS A USER DATA MATRIX IN WHICH COLUMNS REPRESENT SAMPLES AND IF EACH SAMPLE IS COMPLETE (HAS THE SAME NUMBER OF OBSERVATIONS), THE USER CAN EQUIVALENCE X AND XMAT AND ENTER USBOX WITHOUT EXPLICITLY MOVING XMAT INTO X. HOWEVER, THE ROWS OF XMAT WILL NOT BE PRESERVED.

Algorithm

USBOX prints K boxplots. The minimum and maximum from the complete data set, vector X, are printed. The median of each data group is marked by * and the upper and lower hinges by +. The "H-Spread" is the distance between the upper and lower hinges. The observation farthest from the median that still remains within one step (1 1/2 "H-Spread") from each hinge is marked by +. The values in the second step (between 1 1/2 and 3 "H-spreads" from the hinges) are marked by the letter O and the values beyond the second step are marked X. If there are fewer than 5 data points, each data point is plotted with an X. If multiple data points occur at positions marked X or O, the number of multiple points is noted.

See reference:

Tukey, John W., Exploratory Data Analysis, Addison Wesley Publishing Company, Reading, Massachusetts, 1977.

Example

This example prints box plots of three batches of data containing 5, 16 and 7 observations, respectively.

Input:

```
INTEGER         K,NI(3),MAXL,IER
REAL            X(28)
X    = (7.,9.,3.,1.,1.,25.,0.,1.,0.,5.,4.,3.,5.,5.,5.,5.,5.,
        25.,15.,9.,10.,15.,20.,25.,2.,9.,12.)
K    =  3
NI   = (5,16,7)
MAXL =  80
CALL USBOX (X,K,NI,MAXL,IER)
  :
  :
END
```

Output:

```
IER = 0

  .0000E 00                                                    .2500E 02

   X     X           X     X
   2


          +----------+
+---------+    *     +-----+                O                          X
          +----------+                                                  2


                              +---------------------+
      +-----------------------+      *              +------------------+
                              +---------------------+
```

IMSL ROUTINE NAME - USHHST

PURPOSE - PRINT A HORIZONTAL HISTOGRAM

USAGE - CALL USHHST (T,N,IOPT,IER)

ARGUMENTS

T - VECTOR OF LENGTH N CONTAINING THE FREQUENCIES (COUNTS). (INPUT) ELEMENTS MUST BE NON-NEGATIVE.

N - LENGTH OF T VECTOR, (NUMBER OF BARS TO PRINT). N MUST BE A POSITIVE INTEGER. (INPUT)

IOPT - OPTION VECTOR OF LENGTH 5. (INPUT)
IOPT(I) DENOTES,
I=1, SPACING BETWEEN HORIZONTAL HISTOGRAM LINES. 0, 1, OR 2 SPACES ARE ALLOWED.
I=2, ZERO WILL CAUSE A FULL (HORIZONTAL) PAGE HISTOGRAM. IOPT(2)=1 WILL LIMIT THE WIDTH TO EIGHT AND ONE HALF INCHES.
I=3, THE UPPER LIMIT OF THE NUMBER OF LINES TO PRINT WITHIN THE HISTOGRAM PER PAGE. AFTER THAT NUMBER OF LINES IS PRINTED, THE ROUTINE WILL SKIP TO A NEW PAGE TO CONTINUE PRINTING.
IF IOPT(3)=0, THEN THE MAXIMUM NUMBER OF LINES COINCIDES WITH THE STANDARD PRINTER PAGE.
I=4, IF ZERO, THEN, IF MULTIPLE PAGES ARE REQUIRED, THE FREQUENCY LINE (BOTTOM) AND THE CLASS LINE (TOP) ARE REPEATED FOR EACH PAGE. IF NONZERO, THE CLASS AND FREQUENCY WILL BE PRINTED ON THE FIRST AND LAST PAGE OF THE HISTOGRAM, RESPECTIVELY.
I=5, IF ZERO, SKIP TO NEW PAGE BEFORE PRINTING FIRST LINE. IF NONZERO, TWO SPACES ARE SKIPPED AND PRINTING BEGINS ON THE SAME PAGE. IOPT(5) SHOULD BE NONZERO IF THE USER WISHES TO PRINT A TITLE ABOVE THE HISTOGRAM.

IER - ERROR PARAMETER. (OUTPUT)
WARNING WITH FIX ERROR
IER=65 MEANS THAT IOPT(1) IS NOT 0, 1, OR 2. THE ZERO OPTION IS USED FOR IOPT(1).
IER=66 MEANS THAT IOPT(2) IS NOT 0 OR 1. THE ZERO OPTION IS USED FOR IOPT(2).
TERMINAL ERROR
IER=132 MEANS THAT THE LENGTH OF T IS NOT POSITIVE.
IER=133 MEANS THAT THE MAXIMUM ELEMENT OF T IS LESS THAN ONE. THE BODY OF THE HISTOGRAM IS BLANK.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USHHST prints a horizontal histogram on one or more pages, using up to 132 horizontal print positions, and an unlimited number of vertical print positions.

Given a vector containing positive counts, T, USHHST determines the maximum count, TMAX. Horizontal printing on a given line, and the frequency printed relating to the horizontal print position, is obtained as follows, depending on optional requests.

$$K = 1 + (TMAX-1)/60 \quad \text{(for 72 characters);}$$

$$K = 1 + (TMAX-1)/120 \quad \text{(for 132 characters).}$$

If a frequency is greater than K, then a character is printed in the first position. Henceforth, K is increased by K/60 or K/120, for each position, and frequencies are compared to the resulting K.

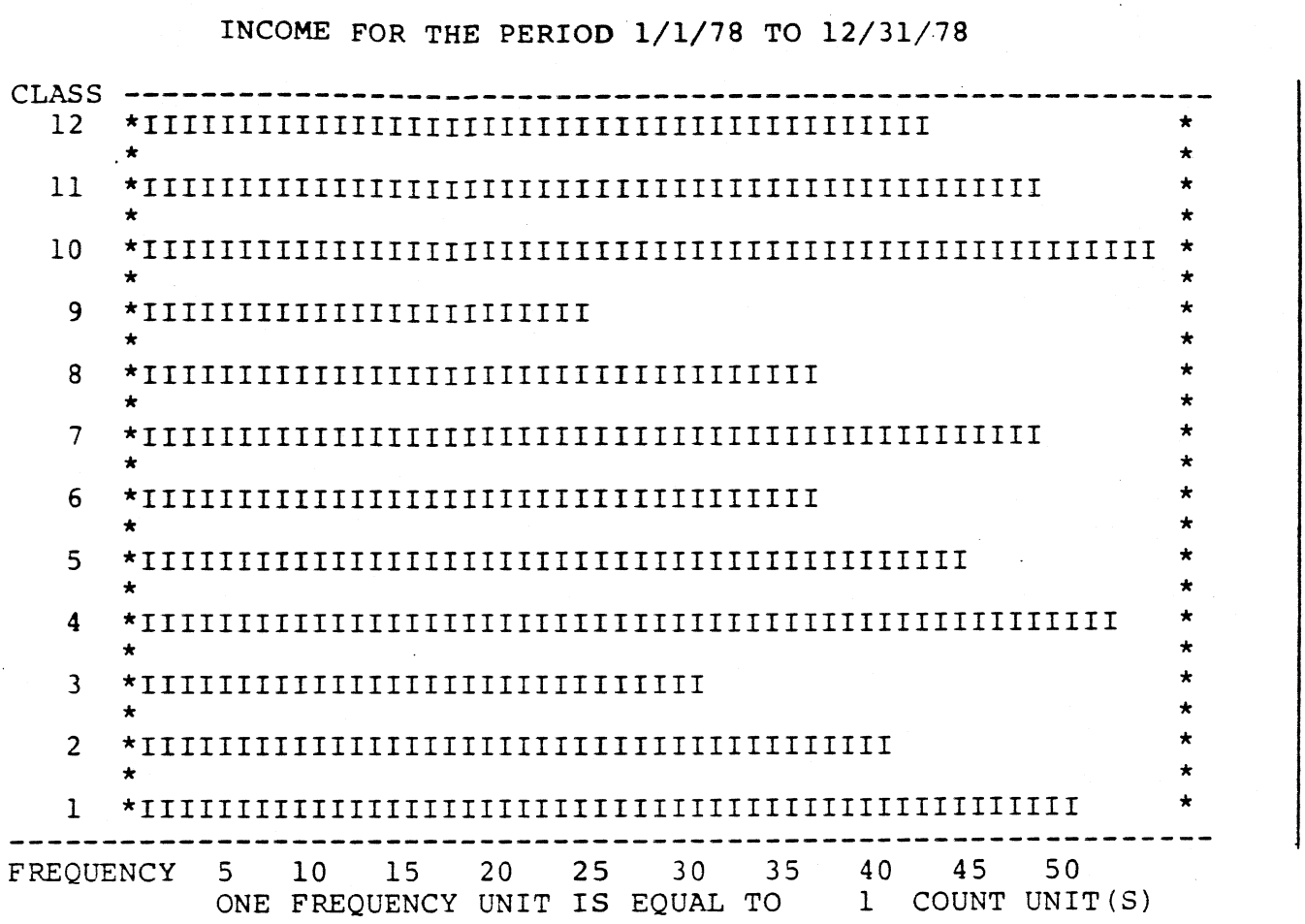
Example

Let T contain twelve months of actual income figures. USHHST would produce a histogram as follows:

Input:

```
  INTEGER   N,IOPT(5),IER
  REAL      T(12)
  T    = (50.,40.,30.,52.,44.,36.,48.,36.,24.,54.,48.,42.)
  N      =  12
  IOPT   = (1,1,0,1,1)
  CALL UGETIO (1,NIN,NOUT)
  WRITE (NOUT,5)
5 FORMAT (12X,40HINCOME FOR THE PERIOD 1/1/78 TO 12/31/78)
  CALL USHHST (T,N,IOPT,IER)
     .
     .
     .
  END
```

Output:


INCOME FOR THE PERIOD 1/1/78 TO 12/31/78
CLASS
12
11
10
9
8
7
6
5
4
3
2
1
FREQUENCY 5 10 15 20 25 30 35 40 45 50
ONE FREQUENCY UNIT IS EQUAL TO 1 COUNT UNIT(S)

IMSL ROUTINE NAME - USHST

PURPOSE - PRINT A VERTICAL HISTOGRAM

USAGE - CALL USHST (T,N,ISP,IER)

ARGUMENTS

T - REAL VECTOR OF LENGTH N CONTAINING THE FREQUENCIES (COUNTS). ELEMENTS MUST BE NON-NEGATIVE. (INPUT)

N - LENGTH OF T, (NUMBER OF BARS TO PRINT). IF N EXCEEDS 100/(ISP+1), N=100/(ISP+1) IS USED. N MUST BE A POSITIVE INTEGER. (INPUT)

ISP - SPACING BETWEEN HISTOGRAM BARS. ISP MAY EQUAL 0,1, OR 4. (INPUT)

IER - ERROR PARAMETER. (OUTPUT)

WARNING ERROR

IER=34 MEANS THAT N*(ISP+1) IS LESS THAN 1 OR GREATER THAN 100. THE WIDTH OF THE HISTOGRAM IS SET TO 100, AND 100/(ISP+1) BARS ARE PRINTED. THE NUMBER OF CLASS INTERVALS WILL BE PRINTED COMPLETELY IF ISP.NE.0 AND WILL ALWAYS BE PRINTED UP TO AND INCLUDING 100/(ISP+1) EVEN THOUGH THE HISTOGRAM BODY IS ONLY 100 SPACES WIDE. IF THE CONDITION OF IER=35 ALSO OCCURS, IER IS SET TO 35.

IER=35 MEANS THAT ISP IS OUT OF ITS RANGE. ISP=0 IS USED.

TERMINAL ERROR

IER=132 MEANS THAT THE LENGTH OF T IS NOT POSITIVE.

IER=133 MEANS THAT THE MAXIMUM ELEMENT OF T IS LESS THAN 1. THE BODY OF THE HISTOGRAM IS BLANK.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS

1. IF N*(ISP+1) .LE. 100, THE HISTOGRAM WILL BE PRINTED CORRECTLY.
2. IF THE MAXIMUM FREQUENCY IS .GT. 9999, THE FREQUENCY COLUMN WILL CONTAIN **** ON SOME LINES.
3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.
4. EACH HISTOGRAM IS PRINTED ON A NEW PAGE. A USER MIGHT SUPPLY A TITLE FOR A HISTOGRAM BY PRINTING LINES OF TEXT AFTER CALLING USHST . THE LENGTH OF THE TEXT SHOULD BE MIN(N(ISP+1)+12,112).

Algorithm

USHST prints a histogram on not more than one printer page, using not more than 50 vertical and 100 horizontal print positions. Spacing control is allowed, on the horizontal axis.

Given a vector containing positive counts, T, USHST determines the maximum count, TMAX. Vertical printing on a given line, and the frequency printed relating to the line, is obtained directly from

$$K = 1+(TMAX-1)/50.$$

If a frequency is greater than K, then a character is printed on the first line. Henceforth, K is reduced by K/50, for each line, and frequencies are compared to the new K.

Example

This example prints a histogram of ten frequencies ranging from 1 to 10.

Input:

```
INTEGER   N,ISP,IER
REAL      T(10)
T   = (4.,5.,2.,3.,6.,10.,4.,4.,3.,6.)
N   =  10
ISP =  1
CALL USHST (T,N,ISP,IER)
   :
   :
END
```

Output:

```
FREQUENCY----------------------
  10  *           I           *
   9  *           I           *
   8  *           I           *
   7  *           I           *
   6  *         I I         I *
   5  *   I     I I         I *
   4  * I I     I I I I     I *
   3  * I I   I I I I I I I I *
   2  * I I I I I I I I I I I *
   1  * I I I I I I I I I I I *
------------------------------
CLASS     2   4   6   8  10
```

IMSL ROUTINE NAME - USHST2

PURPOSE - PRINT A VERTICAL HISTOGRAM, PLOTTING TWO FREQUENCIES WITH ONE BAR OF THE HISTOGRAM

USAGE - CALL USHST2 (T,U,N,ISP,IER)

ARGUMENTS

T - REAL VECTOR OF LENGTH N CONTAINING THE FREQUENCIES (COUNTS). ELEMENTS MUST BE NON-NEGATIVE. (INPUT)

U - REAL VECTOR OF LENGTH N CONTAINING THE FREQUENCIES (NEW COUNTS). ELEMENTS MUST BE NON-NEGATIVE. (INPUT)

N - LENGTH OF T AND U, (NUMBER OF BARS TO PRINT). IF N EXCEEDS 100/(ISP+1), N=100/(ISP+1) IS USED. N MUST BE A POSITIVE INTEGER. (INPUT)

ISP - SPACING BETWEEN HISTOGRAM BARS. (INPUT) ISP=0,1, OR 4 IS ALLOWED.

IER - ERROR PARAMETER. (OUTPUT)

WARNING ERROR

IER=34 MEANS THAT N*(ISP+1) IS LESS THAN 1 OR GREATER THAN 100. THE WIDTH OF THE HISTOGRAM IS SET TO 100, AND 100/(ISP+1) BARS ARE PRINTED. THE NUMBER OF CLASS INTERVALS WILL BE PRINTED COMPLETELY IF ISP.NE.0 AND WILL ALWAYS BE PRINTED UP TO AND INCLUDING 100/(ISP+1) EVEN THOUGH THE HISTOGRAM BODY IS ONLY 100 SPACES WIDE. IF THE CONDITION OF IER=35 ALSO OCCURS, IER IS SET TO 35.

IER=35 MEANS THAT ISP IS OUT OF ITS RANGE. THE ZERO OPTION IS USED FOR ISP.

TERMINAL ERROR

IER=132 MEANS THAT N IS NOT POSITIVE.

IER=133 MEANS THAT THE MAXIMUM VALUE IN T AND U IS LESS THAN ONE. THE BODY OF THE HISTOGRAM IS BLANK.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS

1. IF N*(ISP+1) IS .LE. 100, THE HISTOGRAM WILL BE PRINTED CORRECTLY.
2. IF THE MAXIMUM FREQUENCY IS .GT. 9999, THE FREQUENCY COLUMN WILL CONTAIN **** ON SOME LINES.
3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.
4. EACH HISTOGRAM IS PRINTED ON A NEW PAGE. A USER MIGHT SUPPLY A TITLE FOR A HISTOGRAM BY PRINTING LINES OF TEXT AFTER CALLING USHST2. THE LENGTH OF THE TEXT SHOULD BE MIN(N(ISP+1)+12,112).

Algorithm

USHST2 prints a histogram on not more than one printer page, using not more than 50 vertical and 100 horizontal print positions. Spacing control is allowed, on the horizontal axis.

Given two vectors containing positive counts, T and U, USHST2 determines the maximum count of the combined vectors, TMAX. Vertical printing on a given line, and the frequency printed relating to the line, is obtained directly from

$$K = 1+(TMAX-1)/50.$$

If a frequency is greater than K, then a character is printed on the first line. Henceforth, K is reduced by K/50, for each line, and frequencies are compared to the new K.

The character to be printed is chosen as follows:

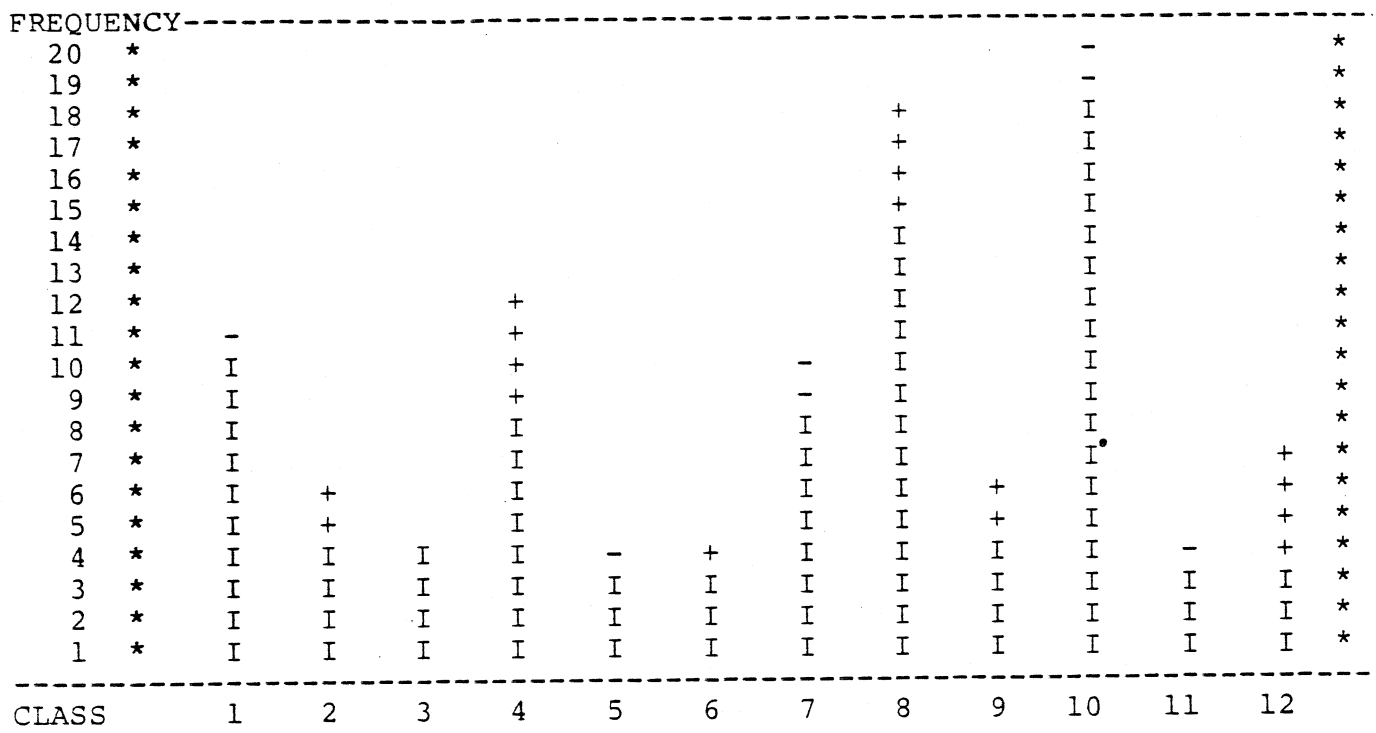
If T(I) is greater than U(I), a minus (-) sign is printed.
If T(I) is less than or equal to U(I), a plus (+) sign is printed.
If any character is to be printed, and the vertical print position K is less than or equal to min(T(I),U(I)), then the character printed is I.

Example

Let U contain twelve months of projected income figures and T contain the same twelve actual income figures. USHST2 would produce a histogram which allowed projected versus actuals to be viewed as follows.

```
      INTEGER   N,ISP,IER
      REAL      T(12),U(12)
      T   = (11.,4.,4.,8.,4.,3.,10.,14.,4.,20.,4.,3.)
      U   = (10.,6.,4.,12.,3.,4.,8.,18.,6.,18.,3.,7.)
      N   =  12
      ISP =  4
      CALL USHST2 (T,U,N,ISP,IER)
      CALL UGETIO (1,NIN,NOUT)
      WRITE (NOUT,5)
    5 FORMAT (/,3X,66H,TWELVE MONTHS PROJECTED SALES VERSUS ACTUAL SALES,
     *        IN THOUSANDS OF,/,3X,65H DOLLARS. A POSITIVE SIGN (+) IMPLIES
     *        PROJECTED EXCEEDED ACTUAL. A,/,3X,52H NEGATIVE SIGN (-)
     *        IMPLIES ACTUAL EXCEEDED PROJECTED.)
         :
         :
      END
```

Output:



TWELVE MONTHS PROJECTED SALES VERSUS ACTUAL SALES, IN THOUSANDS OF DOLLARS. A POSITIVE SIGN (+) IMPLIES PROJECTED EXCEEDED ACTUAL. A NEGATIVE SIGN (-) IMPLIES ACTUAL EXCEEDED PROJECTED.

IMSL ROUTINE NAME - USLEAP

PURPOSE - PRINT RESULTS OF THE BEST-REGRESSIONS ANALYSIS PERFORMED BY IMSL ROUTINE RLEAP.

USAGE - CALL USLEAP (IJOB,KZ,IXS,STAT,IXV,NVAR,IXB, BEST,IB)

ARGUMENTS

IJOB	- INPUT (RLEAP OUTPUT) OPTION AND CONTROL PARAMETER VECTOR OF LENGTH 4.
KZ	- NUMBER OF VARIABLES. (INPUT)
IXS	- INPUT (RLEAP OUTPUT) VECTOR CONTAINING THE LOCATION OF THE FIRST ELEMENT FOR EACH SUBSET SIZE IN STAT.
STAT	- INPUT (RLEAP OUTPUT) VECTOR CONTAINING THE CRITERION VALUES FOR EACH SUBSET CONSIDERED, IN INCREASING SUBSET SIZE ORDER.
IXV	- INPUT (RLEAP OUTPUT) VECTOR CONTAINING THE LOCATION OF THE FIRST ELEMENT FOR EACH SUBSET SIZE IN NVAR.
NVAR	- INPUT (RLEAP OUTPUT) VECTOR CONTAINING THE VARIABLE NUMBERS FOR EACH SUBSET CONSIDERED, ORDERED CORRESPONDINGLY TO STAT.
IXB	- INPUT (RLEAP OUTPUT) VECTOR CONTAINING THE ROW NUMBER OF THE FIRST ROW FOR EACH SUBSET SIZE IN BEST.
BEST	- INPUT (RLEAP OUTPUT) MATRIX CONTAINING THE RESULTS FOR THE BEST REGRESSIONS BEGINNING WITH ONE VARIABLE REGRESSIONS AND INCREASING THE SUBSET SIZE. COLUMNS 1,2,3, AND 4 CONTAIN VARIABLE NUMBER, REGRESSION COEFFICIENT, F VALUE, AND TAIL AREA OF THE F DISTRIBUTION, RESPECTIVELY.
IB	- ROW DIMENSION OF MATRIX BEST EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM. (INPUT)

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - NONE REQUIRED

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USLEAP prints the results of the best regressions analysis performed by IMSL routine RLEAP. It is useful for that purpose only and should be called subsequent to a call to RLEAP.

Results are printed for a number of good regressions, followed by more detailed output for the selected best regressions. Only the criterion values and variable numbers are printed for the good regressions. For the best regressions, regression coefficients, F-values, and F distribution tail areas are printed.

Programming Notes

Input to USLEAP is available directly from RLEAP, without modification, except when the warning error (IER=37) occurs. In that case KZ must be modified prior to calling USLEAP.

```
      CALL UGETIO (1,NIN,NOUT)
      KX = KZ-1
      CALL RLEAP (RR,KZ,IJOB,IXS,STAT,IXV,NVAR,IXB,BEST,IB,WK,IW,IER)
      IF (IER .NE. 37) GO TO 20
      WRITE (NOUT,10) (IW(I),I=1,KX)
   10 FORMAT (21H VARIABLES DELETED = ,20I5)
      ICNT = 0
      DO 15 I=1,KX
         IF (IW(I) .EQ. 0) ICNT=ICNT+1
   15 CONTINUE
      KZ = ICNT+1
   20 CALL USLEAP (IJOB,KZ,IXS,STAT,IXV,NVAR,IXB,BEST,IB)
```

Example

The following example illustrates usage of RLEAP and USLEAP for the sample problem in the Example section of the RLEAP document.

Input:

```
INTEGER    IJOB(4),KZ,IXS(5),IXV(5),NVAR(20),IXB(5),IB,IW(132),IER
REAL       RR(90),STAT(8),BEST(10,4),WK(50)

        [  415.23                                                  ]
        [  251.08     2905.7                                       ]
RR   =  [ -372.62     -166.54    492.31                            ]
        [ -290.00    -3041.0      38.000    3362.0                 ]
        [  775.96     2292.9    -618.23    -2481.7    2715.8       ]

KZ   =  5
IJOB = (12,1,1,2)
IB   =  10
CALL RLEAP (RR,KZ,IJOB,IXS,STAT,IXV,NVAR,IXB,BEST,IB,WK,IW,IER)
CALL USLEAP (IJOB,KZ,IXS,STAT,IXV,NVAR,IXB,BEST,IB)
   :
   :
END
```

Output:

```
REGRESSIONS WITH   1 VARIABLE(S) (R-SQUARED)

       CRITERION          VARIABLES
       0.674533E+02        4
       0.666226E+02        2
```

REGRESSIONS WITH 2 VARIABLE(S) (R-SQUARED)

CRITERION	VARIABLES
0.978634E+02	1 2
0.972456E+02	1 4

REGRESSIONS WITH 3 VARIABLE(S) (R-SQUARED)

CRITERION	VARIABLES
0.982302E+02	1 2 4
0.982242E+02	1 2 3

REGRESSIONS WITH 4 VARIABLE(S) (R-SQUARED)

CRITERION	VARIABLES
0.982339E+02	1 2 3 4

BEST REGRESSIONS WITH 1 VARIABLE(S) (R-SQUARED)

VARIABLE	COEFFICIENT	PARTIAL F	ALPHA
4	-0.738161E+00	0.227975E+02	0.577569E-03

BEST REGRESSIONS WITH 2 VARIABLE(S) (R-SQUARED)

VARIABLE	COEFFICIENT	PARTIAL F	ALPHA
1	0.146831E+01	0.146218E+03	0.774860E-06
2	0.662228E+00	0.208133E+03	0.536442E-06

BEST REGRESSIONS WITH 3 VARIABLE(S) (R-SQUARED)

VARIABLE	COEFFICIENT	PARTIAL F	ALPHA
1	0.145192E+01	0.153716E+03	0.137091E-05
2	0.415709E+00	0.500710E+01	0.520432E-01
4	-0.236905E+00	0.186562E+01	0.205135E+00

BEST REGRESSIONS WITH 4 VARIABLE(S) (R-SQUARED)

VARIABLE	COEFFICIENT	PARTIAL F	ALPHA
1	0.154636E+01	0.430328E+01	0.717334E-01
2	0.505276E+00	0.486535E+00	0.505240E+00
3	0.970508E-01	0.165071E-01	0.900943E+00
4	-0.148840E+00	0.439904E-01	0.839114E+00

IMSL ROUTINE NAME - USMNMX

PURPOSE - DETERMINATION OF THE MINIMUM AND MAXIMUM VALUES OF A VECTOR

USAGE - CALL USMNMX (X,N,INC,XMIN,XMAX)

ARGUMENTS
- X - INPUT VECTOR OF LENGTH N FROM WHICH MINIMUM, MAXIMUM VALUES ARE TO BE TAKEN.
- N - LENGTH OF THE INPUT VECTOR X. (INPUT)
- INC - DISPLACEMENT BETWEEN CONSECUTIVE VALUES OF X TO BE CONSIDERED.
- XMIN - OUTPUT SCALAR CONTAINING MINIMUM VALUE OF X.
- XMAX - OUTPUT SCALAR CONTAINING MAXIMUM VALUE OF X.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - NONE REQUIRED

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

Algorithm

USMNMX determines the minimum and maximum elements of a vector.

Example

This example inputs the 8 element vector X and determines XMIN and XMAX.

Input:

```
REAL    X(8),XMIN,XMAX
INTEGER N,INC
X    = (1.,-2.,3.,-5.,-4.,1.,3.,6.)
N    =  8
INC  =  1
CALL USMNMX (X,N,INC,XMIN,XMAX)
   :
   :
END
```

Output:

```
XMIN =  -5.
XMAX =   6.
```

IMSL ROUTINE NAME - USPC

PURPOSE - PRINT A SAMPLE CDF, A THEORETICAL CDF AND CONFIDENCE BAND INFORMATION. PLOT THESE ON OPTION.

USAGE - CALL USPC (CDF,X,N,N12,N95,IP,IC,W)

ARGUMENTS

CDF - USER SUPPLIED PROBABILITY DISTRIBUTION FUNCTION SUBROUTINE DEFINING THE 2 ARGUMENTS (X,P). X IS THE SAMPLE POINT AND P IS THE RESULTING THEORETICAL PROBABILITY AT THE POINT X (INTEGERAL OF THE DENSITY TO X). CDF MUST APPEAR IN AN EXTERNAL STATEMENT IN THE CALLING PROGRAM. (INPUT)

X - INPUT VECTOR OF LENGTH N CONTAINING SAMPLE OF SIZE N. X MUST BE SORTED INTO ASCENDING ORDER PRIOR TO ENTERING USPC. ON OUTPUT, X IS DESTROYED. (INPUT/OUTPUT)

N - SIZE OF SAMPLE. (INPUT)

N12 - CONFIDENCE BAND OPTION. (INPUT)
IF N12 = 2,TWO-SIDED CONFIDENCE BAND INFORMATION IS DESIRED.
IF N12 = 1, POSITIVE ONE-SIDED CONFIDENCE BAND INFORMATION IS DESIRED.
OTHERWISE, NEGATIVE ONE-SIDED CONFIDENCE BAND INFORMATION IS DESIRED.

N95 - CONFIDENCE BAND OPTION. (INPUT)
IF N95 = 95,THE 95 PER CENT BAND IS DESIRED.
OTHERWISE, THE 99 PER CENT BAND IS DESIRED.

IP - PLOTTING OPTION. (INPUT)
IF IP = 1, A PLOT OF THE SAMPLE VS THE THEORETICAL CDF IS DESIRED.
OTHERWISE, ONLY PRINTING OCCURS.

IC - CONFIDENCE BAND OPTION. (INPUT)
IF IC = 1, CONFIDENCE BAND INFORMATION WILL ALSO BE PLOTTED.

W - WORK AREA OF SIZE 4*N. SEE REMARKS.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UERTST,UGETIO,USPLO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS

1. IF A GRAPH IS REQUESTED, THE USER MUST COMPLETE THE GRAPH BY CONNECTING THE POINTS AND REMEMBERING THAT SAMPLE CDFS ARE STEP FUNCTIONS.
2. W MAY BE DIMENSIONED 3N INSTEAD OF 4N FOR A ONE-SIDED CONFIDENCE BAND.
3. CONFIDENCE BANDS ARE PLOTTED AROUND THE SAMPLE CDF.

Algorithm

USPC prints the sample cumulative probability distribution function (cdf), the theoretical cdf and confidence bands on the cdf's. On option, the sample and theoretical cdf will be plotted with or without the confidence band information.

The sample cdf is calculated. (For printing and plotting, duplicate X points are eliminated.) The theoretical cdf is calculated by calling a user supplied subroutine CDF. Asymptotic critical values are used (from the Smirnov tables) for confidence interval calculations.

See reference:

Kendall, M. G., and Stuart, A., The Advanced Theory of Statistics, Vol. II, Hafner Publishing Company, New York, 1961, 457.

Example

This example prints and plots a sample cdf, a theoretical cdf and two-sided 95 percent band information using 70 samples.

Input:

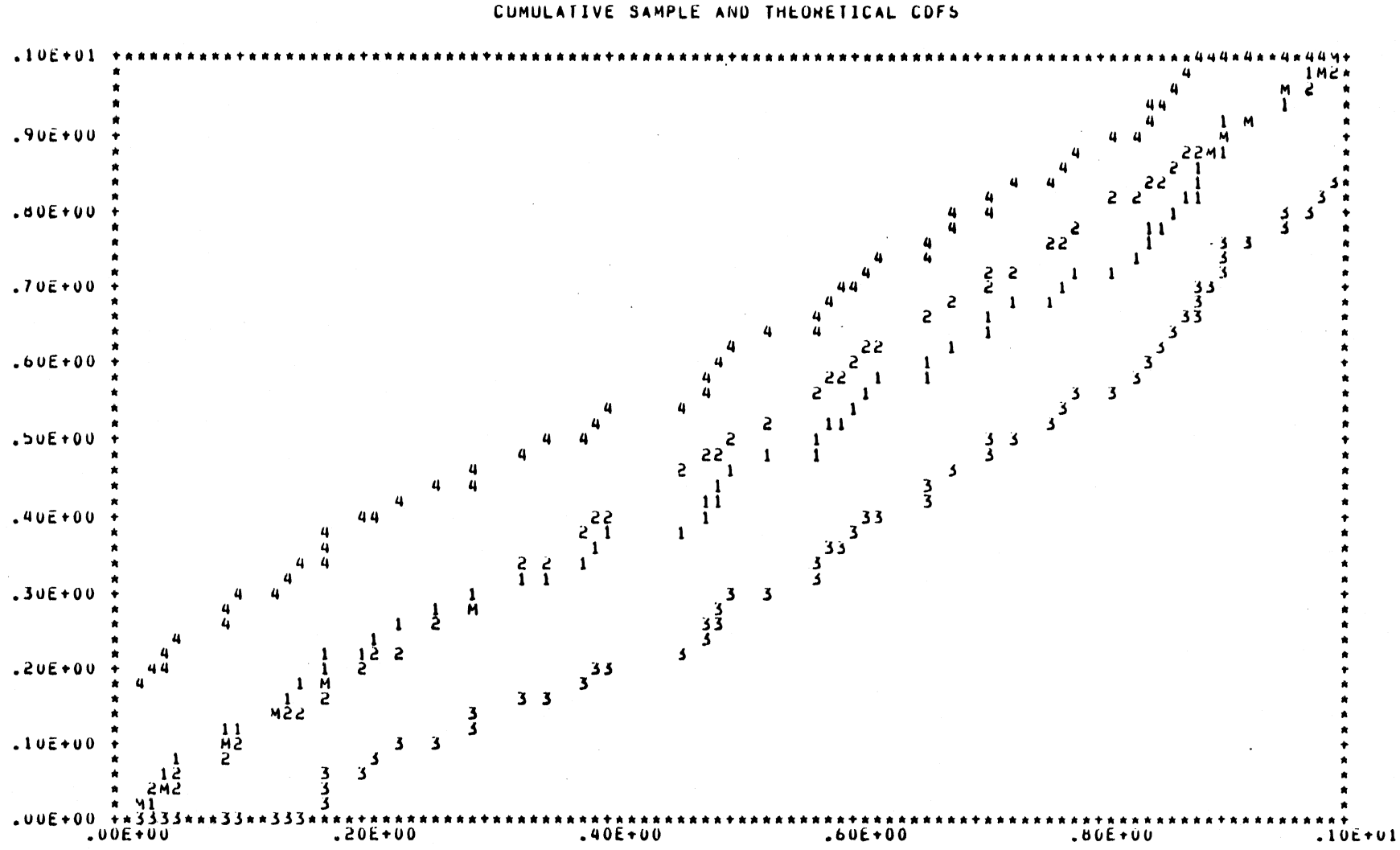
```
DOUBLE PRECISION   DSEED
INTEGER            N,N12,N95,IP,IC
REAL               X(70),W(280)
EXTERNAL           TUSPD
DSEED =  123457.D0
N     =  70
N12   =  2
N95   =  95
IP    =  1
IC    =  1
CALL GGUBS (DSEED,N,X)
CALL VSRTA (X,N)
CALL USPC (TUSPD,X,N,N12,N95,IP,IC,W)
   :
   :
END

SUBROUTINE TUSPD (X,P)
P     =  X
RETURN
END
```

Output:

X	FN(X)	F(X)	95 PER CENT BAND
0.159807E-01	0.142857E-01	0.159807E-01	(0.000000E 00, 0.176610E 00)
0.325987E-01	0.285714E-01	0.325987E-01	(0.000000E 00, 0.190895E 00)
0.429075E-01	0.428571E-01	0.429075E-01	(0.000000E 00, 0.205181E 00)
0.442665E-01	0.571429E-01	0.442665E-01	(0.000000E 00, 0.219467E 00)
0.460945E-01	0.714285E-01	0.460945E-01	(0.000000E 00, 0.233752E 00)
0.513196E-01	0.857142E-01	0.513196E-01	(0.000000E 00, 0.248038E 00)
0.895100E-01	0.999999E-01	0.895100E-01	(0.000000E 00, 0.262324E 00)
0.901860E-01	0.114286E 00	0.901860E-01	(0.000000E 00, 0.276609E 00)
0.104605E 00	0.128571E 00	0.104605E 00	(0.000000E 00, 0.290895E 00)
0.131007E 00	0.142857E 00	0.131007E 00	(0.000000E 00, 0.305181E 00)
0.142117E 00	0.157143E 00	0.142117E 00	(0.000000E 00, 0.319467E 00)
0.145792E 00	0.171429E 00	0.145792E 00	(0.910443E-02, 0.333752E 00)
0.169049E 00	0.185714E 00	0.169049E 00	(0.233901E-01, 0.348038E 00)
0.169364E 00	0.200000E 00	0.169364E 00	(0.376756E-01, 0.362324E 00)
0.173783E 00	0.214285E 00	0.173783E 00	(0.519615E-01, 0.376609E 00)
0.196769E 00	0.228571E 00	0.196769E 00	(0.662472E-01, 0.390895E 00)
0.213078E 00	0.242857E 00	0.213078E 00	(0.805328E-01, 0.405181E 00)
0.225801E 00	0.257142E 00	0.225801E 00	(0.948185E-01, 0.419466E 00)
0.260711E 00	0.271428E 00	0.260711E 00	(0.109104E 00, 0.433752E 00)
0.287973E 00	0.285714E 00	0.287973E 00	(0.123390E 00, 0.448038E 00)
0.289397E 00	0.299999E 00	0.289397E 00	(0.137676E 00, 0.462323E 00)
0.330512E 00	0.314285E 00	0.330512E 00	(0.151961E 00, 0.476609E 00)
0.345995E 00	0.328571E 00	0.345995E 00	(0.166247E 00, 0.490895E 00)
0.380654E 00	0.342857E 00	0.380854E 00	(0.180533E 00, 0.505180E 00)
0.394975E 00	0.357142E 00	0.394975E 00	(0.194818E 00, 0.519466E 00)
0.402428E 00	0.371428E 00	0.402428E 00	(0.209104E 00, 0.533752E 00)
0.461225E 00	0.385714E 00	0.461225E 00	(0.223390E 00, 0.548037E 00)
0.478770E 00	0.399999E 00	0.478770E 00	(0.237675E 00, 0.562323E 00)
0.479442E 00	0.414285E 00	0.479442E 00	(0.251961E 00, 0.576609E 00)
0.485099E 00	0.428571E 00	0.485099E 00	(0.266247E 00, 0.590895E 00)
0.488735E 00	0.442856E 00	0.488735E 00	(0.280532E 00, 0.605180E 00)
0.502506E 00	0.457142E 00	0.502506E 00	(0.294818E 00, 0.619466E 00)
0.528683E 00	0.471428E 00	0.528683E 00	(0.309104E 00, 0.633752E 00)
0.565949E 00	0.485713E 00	0.565949E 00	(0.323389E 00, 0.648037E 00)
0.569337E 00	0.499999E 00	0.569337E 00	(0.337675E 00, 0.662323E 00)
0.581051E 00	0.514285E 00	0.581051E 00	(0.351961E 00, 0.676609E 00)
0.587046E 00	0.528570E 00	0.587046E 00	(0.366247E 00, 0.690894E 00)
0.601350E 00	0.542856E 00	0.601350E 00	(0.380532E 00, 0.705180E 00)
0.611003E 00	0.557142E 00	0.611003E 00	(0.394818E 00, 0.719466E 00)
0.616272E 00	0.571427E 00	0.616272E 00	(0.409104E 00, 0.733751E 00)
0.659239E 00	0.585713E 00	0.659239E 00	(0.423389E 00, 0.748037E 00)
0.659676E 00	0.599999E 00	0.659676E 00	(0.437675E 00, 0.762323E 00)
0.679700E 00	0.614285E 00	0.679700E 00	(0.451961E 00, 0.776608E 00)
0.683385E 00	0.628570E 00	0.683385E 00	(0.466246E 00, 0.790894E 00)
0.709518E 00	0.642856E 00	0.709518E 00	(0.480532E 00, 0.805180E 00)
0.710685E 00	0.657142E 00	0.710685E 00	(0.494818E 00, 0.819465E 00)
0.727393E 00	0.671427E 00	0.727393E 00	(0.509103E 00, 0.833751E 00)
0.756820E 00	0.685713E 00	0.756820E 00	(0.523389E 00, 0.848037E 00)
0.766262E 00	0.699999E 00	0.766262E 00	(0.537675E 00, 0.862323E 00)
0.776550E 00	0.714284E 00	0.776550E 00	(0.551960E 00, 0.876608E 00)

X	FN(X)	F(X)	95 PER CENT BAND
0.812855E 00	0.728570E 00	0.812855E 00	(0.566246E 00, 0.890894E 00)
0.826469E 00	0.742856E 00	0.826469E 00	(0.580532E 00, 0.905180E 00)
0.839578E 00	0.757141E 00	0.839578E 00	(0.594817E 00, 0.919465E 00)
0.844829E 00	0.771427E 00	0.844829E 00	(0.609103E 00, 0.933751E 00)
0.849817E 00	0.785713E 00	0.849817E 00	(0.623389E 00, 0.948037E 00)
0.856955E 00	0.799998E 00	0.856955E 00	(0.637675E 00, 0.962322E 00)
0.873329E 00	0.814284E 00	0.873329E 00	(0.651960E 00, 0.976608E 00)
0.875223E 00	0.828570E 00	0.875223E 00	(0.666246E 00, 0.990894E 00)
0.879598E 00	0.842855E 00	0.879598E 00	(0.680532E 00, 0.100000E 01)
0.883016E 00	0.857141E 00	0.883016E 00	(0.694817E 00, 0.100000E 01)
0.887218E 00	0.871427E 00	0.887218E 00	(0.709103E 00, 0.100000E 01)
0.896375E 00	0.885713E 00	0.896375E 00	(0.723389E 00, 0.100000E 01)
0.898330E 00	0.899998E 00	0.898330E 00	(0.737674E 00, 0.100000E 01)
0.898750E 00	0.914284E 00	0.898750E 00	(0.751960E 00, 0.100000E 01)
0.918259E 00	0.928570E 00	0.918259E 00	(0.766246E 00, 0.100000E 01)
0.952169E 00	0.942855E 00	0.952169E 00	(0.780531E 00, 0.100000E 01)
0.954367E 00	0.957141E 00	0.954367E 00	(0.794817E 00, 0.100000E 01)
0.966220E 00	0.971427E 00	0.966220E 00	(0.809103E 00, 0.100000E 01)
0.976555E 00	0.985712E 00	0.976555E 00	(0.823388E 00, 0.100000E 01)
0.987184E 00	0.100000E 01	0.987184E 00	(0.837676E 00, 0.100000E 01)



SAMPLE CDF = 1 THEORETICAL CDF = 2

CONFIDENCE BANDS = 3 AND 4

IMSL ROUTINE NAME - USPDF

PURPOSE - PLOT OF TWO SAMPLE CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS AGAINST THEIR SPECTRA

USAGE - CALL USPDF (X,N,M,W,IW,IR)

ARGUMENTS
- X - INPUT VECTOR CONTAINING SAMPLE ONE FOLLOWED BY SAMPLE TWO. X HAS LENGTH N+M. ON OUTPUT, X IS DESTROYED.
- N - SIZE OF SAMPLE ONE. (INPUT)
- M - SIZE OF SAMPLE TWO. (INPUT)
- W - (N+M) BY 2 MATRIX, USED AS WORK STORAGE.
- IW - ROW DIMENSION OF MATRIX W EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM. (INPUT)
- IR - ARRAY OF SIZE N+M USED AS WORK STORAGE.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - CERTST,UGETIO,USPLO,USPKD,VSRTR

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS
1. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.
2. THE PLOTTED FUNCTIONS ARE STEP FUNCTIONS. THE POINTS PLOTTED SHOULD BE CONNECTED BY THE USER STARTING AT THE LOWER LEFT CORNER OF THE GRAPH.

Algorithm

USPDF plots two sample cumulative probability distribution functions (cdf's) against their spectra.

The two samples are merged and sorted. The cumulative distribution functions are calculated. Duplicate points are eliminated from the plot.

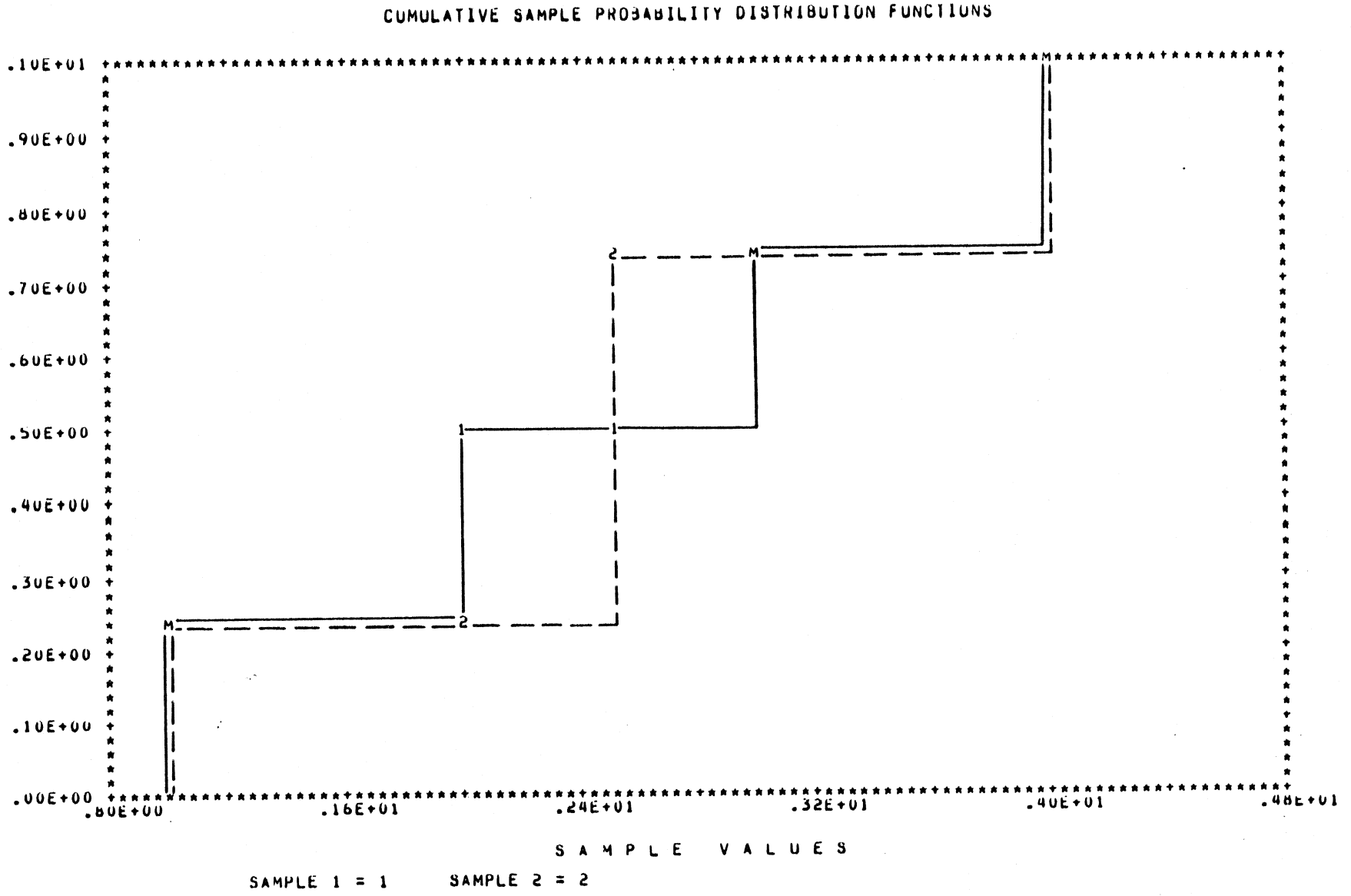
Example

This example plots two sample cdf's (of length 4) against their spectra.

Input:

```
INTEGER   N,M,IW,IR(8)
REAL      X(8),W(8,2)
X  = (4.,3.,2.,1.,2.5,2.5,4.,1.)
N  =  4
M  =  4
IW =  8
CALL USPDF (X,N,M,W,IW,IR)
   .
   .
   .
END
```


Output:


CUMULATIVE SAMPLE PROBABILITY DISTRIBUTION FUNCTIONS
.10E+01
.90E+00
.80E+00
.70E+00
.60E+00
.50E+00
.40E+00
.30E+00
.20E+00
.10E+00
.00E+00
PROBABILITY
.80E+00
.16E+01
.24E+01
.32E+01
.40E+01
.48E+01
SAMPLE VALUES
SAMPLE 1 = 1
SAMPLE 2 = 2

IMSL ROUTINE NAME - USPLO

PURPOSE - PRINTER PLOT OF UP TO TEN FUNCTIONS

USAGE - CALL USPLO (X,Y,IY,N,M,INC,ITITLE,NTITLE, IXLABL,NXLABL,IYLABL,NYLABL,FANGE,ICHAR, IOPT,IER)

ARGUMENTS

X - VECTOR OF LENGTH N CONTAINING THE INDEPENDENT VARIABLE VALUES. (INPUT)

Y - MATRIX OF DIMENSION N BY M CONTAINING THE M SETS OF FUNCTION VALUES. (INPUT)

IY - ROW DIMENSION OF MATRIX Y EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM. (INPUT)

N - LENGTH OF THE X VECTOR. (INPUT)

M - NUMBER OF FUNCTIONS TO BE PLOTTED. (INPUT)

INC - DISPLACEMENT BETWEEN ELEMENTS OF THE VECTOR X TO BE USED. USPLO PLOTS X(1+(I-1)*INC) FOR I=1,...N. (INPUT)

ITITLE - CHARACTER STRING USED AS THE PLOT TITLE. (INPUT) THE LENGTH OF ITITLE MUST NOT EXCEED 72.

NTITLE - LENGTH OF ITITLE. (INPUT) IF NTITLE IS 0 THE TITLE IS LEFT BLANK.

IXLABL - CHARACTER STRING USED TO LABEL THE X AXIS. (INPUT) THE LENGTH OF IXLABL MUST NOT EXCEED 36.

NXLABL - LENGTH OF IXLABL. (INPUT) IF NXLABL IS 0 THE X-AXIS LABEL IS LEFT BLANK.

IYLABL - CHARACTER STRING USED TO LABEL THE Y AXIS. (INPUT) THE LENGTH OF IYLABL MUST NOT EXCEED 36.

NYLABL - LENGTH OF IYLABL. (INPUT) IF NYLABL IS 0 THE Y-AXIS LABEL IS LEFT BLANK.

RANGE - VECTOR OF LENGTH 4 SPECIFYING MINIMUM AND MAXIMUM RANGES FOR X,Y AXES. (INPUT) (MIN X, MAX X, MIN Y, MAX Y, RESPECTIVELY). USPLO WILL CALCULATE EACH AXIS RANGE IF THE MIN AND MAX OF THAT RANGE ARE SET TO 0.0.

ICHAR - CHARACTER STRING OF LENGTH M TO DEFINE THE SYMBOLS TO BE USED TO PLOT THE M FUNCTIONS. (INPUT)

IOPT - INPUT OPTION INDICATING NUMBER OF PRINTER COLUMNS AVAILABLE.
IOPT=0, 80 COLUMNS.
IOPT=1, 129 COLUMNS.

IER - ERROR PARAMETER. (OUTPUT)
WARNING ERROR (WITH FIX)
IER=65 IMPLIES M IS LESS THAN 1.
ONE FUNCTION IS PLOTTED.
IER=66 IMPLIES M IS GREATER THAN 10.
ONLY 10 FUNCTIONS ARE PLOTTED.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UERTST,UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS
1. THE PLOT TITLE AND AXIS LABELS ARE AUTOMATICALLY CENTERED.
2. FOR MULTIPLE PLOTS, THE CHARACTER M IS USED IN THE EVENT THE SAME PRINT POSITION IS SHARED BY TWO OR MORE FUNCTIONS.
3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USPLO provides a printer plot of up to ten functions superimposed upon the same plot.

The user may specify the X- and Y-axis plot ranges and/or plotting symbols and/or plot width.

Minimum and maximum values for both the independent (X vector) and dependent (Y matrix) variables are determined in USPLO or may be obtained from the input array, RANGE.

The print positions ($\bar{X}_i$) and the line numbers ($\bar{Y}_i$) corresponding to the values in X and Y, respectively are computed as linear functions of the input values. The plot width, W, is specified via variable IOPT to be 60 or 100 columns.

$$\bar{X}_i = \left(\frac{W}{X_{max}-X_{min}}\right)(X_i) + \left[1 - \left(\frac{W}{X_{max}-X_{min}}\right) X_{min}\right]$$

$$\bar{Y}_i = \left(\frac{50}{Y_{min}-Y_{max}}\right)(Y_i) + \left[1 - \left(\frac{50}{Y_{min}-Y_{max}}\right) Y_{max}\right]$$

The axes are computed as follows:

$$\bar{X}_{axis} = 1 - \left(\frac{W}{X_{max}-X_{min}}\right)(X_{min})$$

$$\bar{Y}_{axis} = 1 - \left(\frac{50}{Y_{min}-Y_{max}}\right)(Y_{max})$$

Programming Notes

Error detection within USPLO is limited to an examination of the input parameter, M, which defines the number of sets of functional values to be plotted. The value of M is constrained within the range 1 to 10, inclusive.

Example

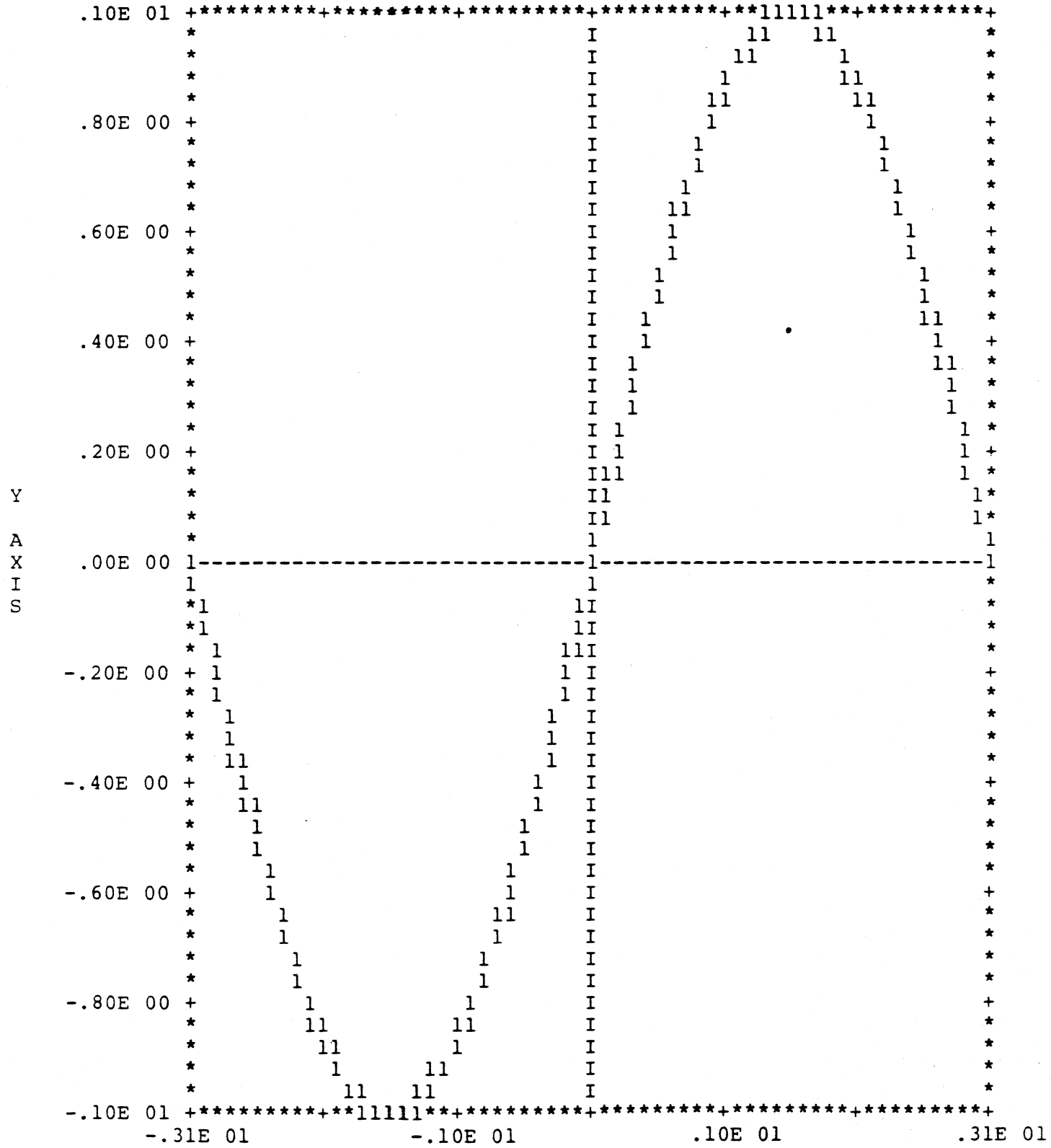
This example plots the sine function over 80 columns. USPLO calculates the Y range.

Input:

```
      INTEGER    I,IY,N,M,INC,IOPT,IER
      REAL       X(200),Y(200,1),RANGE(4),DELX
      DATA       RANGE/-3.14,3.14,0.0,0.0/
C                              UGETIO IS CALLED HERE TO SET NIN TO THE
C                              APPROPRIATE UNIT NUMBER FOR READING INPUT
      X(1)   = -3.1416
      Y(1,1)=  0.
      DELX   =  6.2832/199.
      DO 10 I=2,200
         X(I) = DELX + X(I-1)
         Y(I,1) = SIN(X(I))
   10 CONTINUE
      INC    =  1
      N      =  200
      M      =  1
      IOPT   =  0
      IY     =  200
      CALL USPLO (X,Y,IY,N,M,INC,                    { HOLLERITH form
     *            18HTEST OF USPLO PLOT,18,
     *            6HX AXIS,6,6HY AXIS,6,
     *            RANGE,1H1,IOPT,IER)
   or CALL USPLO (X,Y,IY,N,M,INC,                    { CHARACTER form
     *            'TEST OF USPLO PLOT',18,
     *            'X AXIS',6,'Y AXIS',6,
     *            RANGE,'1',IOPT,IER)
          :                                          { See INTRO Section 5.3
          :                                          { for details
      END
```

Output:

TEST OF USPLO PLOT



X A X I S

IMSL ROUTINE NAME - USPLOD

PURPOSE - PRINTER PLOT OF UP TO TEN FUNCTIONS (DOUBLE PRECISION VERSION)

USAGE - CALL USPLOD (X,Y,IY,N,M,INC,ITITLE,NTITLE, IXLABL,NXLABL,IYLABL,NYLABL,RANGE,ICHAR, IOPT,IER)

ARGUMENTS

X - DOUBLE PRECISION VECTOR OF LENGTH N CONTAINING THE INDEPENDENT VARIABLE VALUES. (INPUT)

Y - DOUBLE PRECISION MATRIX OF DIMENSION N BY M CONTAINING THE M SETS OF FUNCTION VALUES. (INPUT)

IY - ROW DIMENSION OF MATRIX Y EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM. (INPUT)

N - LENGTH OF THE X VECTOR. (INPUT)

M - NUMBER OF FUNCTIONS TO BE PLOTTED. (INPUT)

INC - DISPLACEMENT BETWEEN ELEMENTS OF THE VECTOR X TO BE USED. USPLOD PLOTS X(1+(I-1)*INC) FOR I=1,...N. (INPUT)

ITITLE - CHARACTER STRING USED AS THE PLOT TITLE. (INPUT) THE LENGTH OF ITITLE MUST NOT EXCEED 72.

NTITLE - LENGTH OF ITITLE. (INPUT) IF NTITLE IS 0 THE TITLE IS LEFT BLANK.

IXLABL - CHARACTER STRING USED TO LABEL THE X AXIS. (INPUT) THE LENGTH OF IXLABL MUST NOT EXCEED 36.

NXLABL - LENGTH OF IXLABL. (INPUT) IF NXLABL IS 0 THE X-AXIS LABEL IS LEFT BLANK.

IYLABL - CHARACTER STRING USED TO LABEL THE Y AXIS. (INPUT) THE LENGTH OF IYLABL MUST NOT EXCEED 36.

NYLABL - LENGTH OF IYLABL. (INPUT) IF NYLABL IS 0 THE Y-AXIS LABEL IS LEFT BLANK.

RANGE - DOUBLE PRECISION VECTOR OF LENGTH 4 SPECIFYING MIN AND MAX RANGES FOR X,Y AXES. (INPUT) (MIN X, MAX X, MIN Y, MAX Y, RESPECTIVELY). USPLOD WILL CALCULATE EACH AXIS RANGE IF THE MIN AND MAX OF THAT RANGE ARE SET TO 0.0.

ICHAR - CHARACTER STRING OF LENGTH M TO DEFINE THE SYMBOLS TO BE USED TO PLOT THE M FUNCTIONS. (INPUT)

IOPT - INPUT OPTION INDICATING NUMBER OF PRINTER COLUMNS AVAILABLE.
IOPT=0, 80 COLUMNS.
IOPT=1, 129 COLUMNS.

IER - ERROR PARAMETER. (OUTPUT)
WARNING ERROR (WITH FIX)
IER=65 IMPLIES M IS LESS THAN 1.
ONE FUNCTION IS PLOTTED.
IER=66 IMPLIES M IS GREATER THAN 10.
ONLY 10 FUNCTIONS ARE PLOTTED.

PRECISION/HARDWARE - DOUBLE/H32
- NOT AVAILABLE/H36,H48,H60

REQD. IMSL ROUTINES - UERTST,UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS
1. THE PLOT TITLE AND AXIS LABELS ARE AUTOMATICALLY CENTERED.
2. FOR MULTIPLE PLOTS, THE CHARACTER M IS USED IN THE EVENT THE SAME PRINT POSITION IS SHARED BY TWO OR MORE FUNCTIONS.
3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USPLOD provides a printer plot of up to ten functions in double precision superimposed upon the same plot.

The user may specify the X- and Y-axis plot ranges and/or plotting symbols and/or plot width.

Minimum and maximum values for both the independent (X vector) and dependent (Y matrix) variables are determined in USPLOD or may be obtained from the input array, RANGE.

The print positions ($\bar{X}_i$) and the line numbers ($\bar{Y}_i$) corresponding to the values in X and Y, respectively are computed as linear functions of the input values. The plot width, W, is specified via variable IOPT to be 60 or 100 columns.

$$\bar{X}_i = \left(\frac{W}{X_{max}-X_{min}}\right)(X_i) + \left[1 - \left(\frac{W}{X_{max}-X_{min}} \quad X_{min}\right)\right]$$

$$\bar{Y}_i = \left(\frac{50}{Y_{min}-Y_{max}}\right)(Y_i) + \left[1 - \left(\frac{50}{Y_{min}-Y_{max}} \quad Y_{max}\right)\right]$$

The axes are computed as follows:

$$\bar{X}_{axis} = 1 - \left(\frac{W}{X_{max}-X_{min}}\right)(X_{min})$$

$$\bar{Y}_{axis} = 1 - \left(\frac{50}{Y_{min}-Y_{max}}\right)(Y_{max})$$

Example

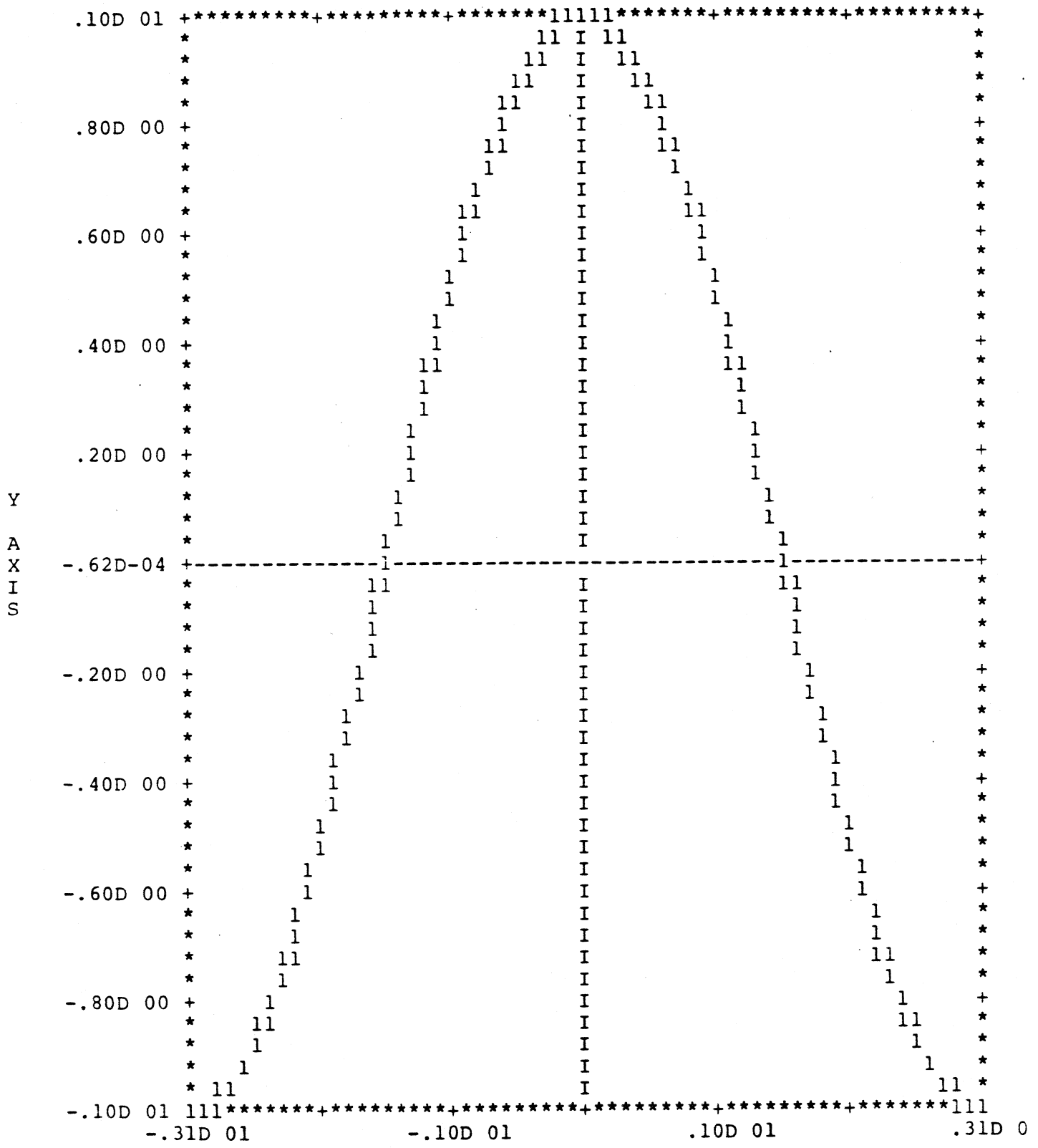
This example plots the cosine function over 80 columns. USPLOD calculates the Y range.

Input:

```
      INTEGER              IY,N,M,INC,IOPT,IER,I
      DOUBLE PRECISION     DELX,RANGE(4),X(200),Y(200,1)
      DATA                 RANGE/-3.14D0,3.14D0,2*0.0D0/
C                            UGETIO IS CALLED HERE TO SET NIN TO THE
C                            APPROPRIATE UNIT NUMBER FOR READING INPUT
      X(1)   = -3.1416D0
      Y(1,1)=  1.0D0
      DELX   =  6.2832D0/199.0D0
      DO 10 I=2,200
         X(I) = DELX + X(I-1)
         Y(I,1) = DCOS(X(I))
   10 CONTINUE
      INC    =  1
      N      =  200
      M      =  1
      IOPT   =  0
      IY     =  200
      CALL USPLOD (X,Y,IY,N,M,INC,                    { HOLLERITH form
     *             19HTEST OF USPLOD PLOT,19,
     *             6HX AXIS,6,6HY AXIS,6,
     *             RANGE,1H1,IOPT,IER)
   or CALL USPLOD (X,Y,IY,N,M,INC,                    { CHARACTER form
     *             'TEST OF USPLOD PLOT',19,
     *             'X AXIS',6,'Y AXIS',6,
     *             RANGE,'1',IOPT,IER)
         :                                            { See INTRO Section 5.3
         :                                            { for details
      END
```

Output:

TEST OF USPLOD PLOT



IMSL ROUTINE NAME - USPRP

PURPOSE - PROBABILITY PLOT

USAGE - CALL USPRP (X,N,N1,N2,IDIST,IOPT,WK,IER)

ARGUMENTS

X - VECTOR OF LENGTH N2-N1+1 CONTAINING THE DATA. THE DATA SET IS POSSIBLY A CENSORED ONE FROM A COMPLETE SAMPLE OF SIZE N. (INPUT)

N - TOTAL NUMBER OF OBSERVATIONS IN UNCENSORED SAMPLE. N MUST BE GREATER THAN OR EQUAL TO N2-N1+1. IF THERE HAS BEEN NO CENSORING THEN N1=1 AND N2=N. (INPUT)

N1 - ON INPUT, N1 IS THE RANK NUMBER OF THE SMALLEST OBSERVATION IN X IF RANKED IN THE COMPLETE SAMPLE. (THE NUMBER OF OBSERVATIONS THAT HAVE BEEN CENSORED FROM BELOW IS N1-1.)
IF, BECAUSE PROPERTIES OF SAMPLE IN X DO NOT MATCH THOSE OF THE DISTRIBUTION SPECIFIED, IT IS NECESSARY FOR USPRP TO DELETE THE SMALLEST K ITEMS IN X, N1 ON OUTPUT IS K PLUS THE INPUT VALUE OF N1. (INPUT/OUTPUT)

N2 - ON INPUT, N2 IS THE RANK NUMBER OF THE LARGEST OBSERVATION IN X IF RANKED IN THE COMPLETE SAMPLE. (THE NUMBER OF OBSERVATIONS THAT HAVE BEEN CENSORED FROM ABOVE IS N-N2.)
IF, BECAUSE PROPERTIES OF SAMPLE IN X DO NOT MATCH THOSE OF THE DISTRIBUTION SPECIFIED, IT IS NECESSARY FOR USPRP TO DELETE THE LARGEST L ITEMS IN X, N2 ON OUTPUT IS L PLUS THE INPUT VALUE OF N2. (INPUT/OUTPUT)

IDIST - PARAMETER TO INDICATE DISTRIBUTION. (INPUT)
IDIST=1, NORMAL DISTRIBUTION.
IDIST=2, LOGNORMAL DISTRIBUTION.
IDIST=3, HALF-NORMAL DISTRIBUTION.
IDIST=4, EXPONENTIAL DISTRIBUTION.
IDIST=5, WEIBULL DISTRIBUTION.
IDIST=6, EXTREME VALUE DISTRIBUTION.

IOPT - OPTION INDICATING NUMBER OF PRINTER COLUMNS AVAILABLE. (INPUT)
IOPT=0, 80 COLUMNS.
IOPT=1, 129 COLUMNS.

WK - WORK VECTOR OF LENGTH 2N.

IER - ERROR PARAMETER. (OUTPUT)
WARNING WITH FIX ERROR
IER = 67 INDICATES THAT IT WAS NECESSARY TO DELETE SOME ITEMS FROM THE PLOTTING BECAUSE THOSE ITEMS DID NOT SATISFY PROPERTIES OF THE DISTRIBUTION.

TERMINAL ERROR
IER=131 INDICATES THAT N1 OR N2 IS SPECIFIED INCORRECTLY.
IER = 132 INDICATES THAT THE SAMPLE SIZE IS LESS THAN 2.
IER = 133 INDICATES IDIST IS SPECIFIED INCORRECTLY.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - MDNRIS,MERFI,UERTST,UGETIO,VSRTA

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USPRP sorts the data in X and plots the observed values along the vertical axis and the ranks along the horizontal axis. In the case of the lognormal and Weibull distributions, the vertical axis has a log scale. The horizontal axis has the appropriate cumulative distribution function scale. For the normal and lognormal distributions, the horizontal plotting distance for the observation with rank I (out of N) is proportional to the inverse normal cumulative distribution function evaluated at (3*I-1)/(3*N+1). For the half-normal plot, the corresponding horizontal distribution is proportional to the inverse normal cumulative distribution function evaluated at (3*N+3*I-1)/(6*N+1). For the other plots, the horizontal distances are proportional to the respective inverse cumulative distribution functions evaluated at (I-.5)/N.

In USPRP it is assumed that the N1-1 smallest observations and the N-N2 largest observations have been censored. (If there has been no censoring, N1 should be set to 1 and N2 set to N.) The smallest observation in X is plotted against the expected value (or the approximate expected value) of the (N1)th order statistic from a sample of size N; the next smallest observation in X is plotted as if it were the (N1+1)th sample order statistic; and so on.

USPRP does not do any shifting of location of the data in X. If any observations fall outside of the range of the distribution (that is, if any observations are nonpositive when the distribution specified is lognormal or Weibull), those observations are censored and N1 or N2 is modified to reflect the number censored. The error parameter IER is set to 67 in this case.

A plot which is a straight line provides evidence that the sample is from the distribution specified.

Example

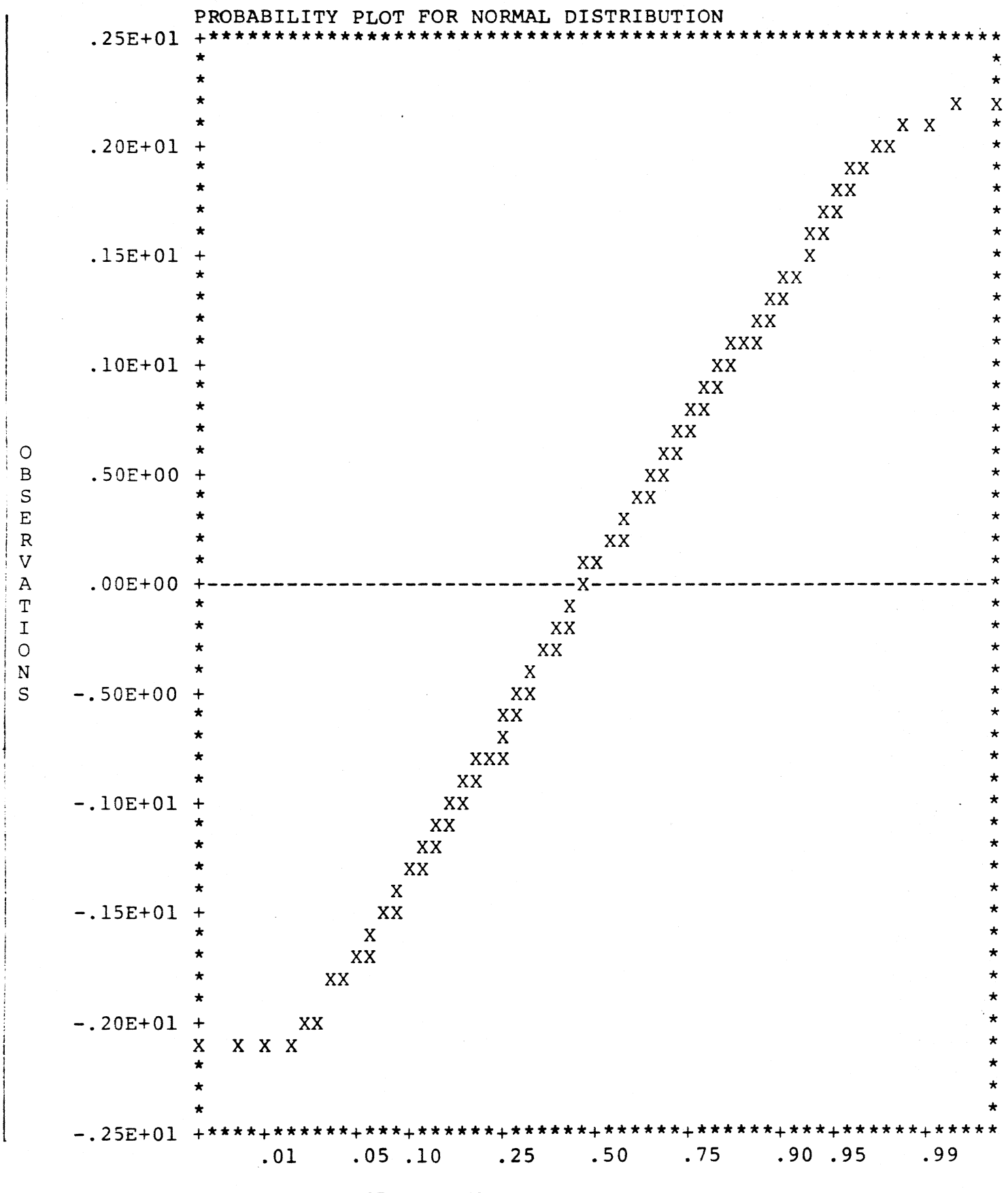
In this example a sample of size 250 (artificially generated from a normal distribution by IMSL routine GGNML) is plotted by USPRP against

a normal distribution function. The generally straight line produced is an indication that the sample is from a normal distribution.

Input:

```
DOUBLE PRECISION    DSEED
INTEGER             N,N1,N2,IDIST,IOPT,IER
REAL                X(250),WK(500)
DSEED = 123457.D0
N     = 250
N1    = 1
N2    = N
CALL GGNML (DSEED,N,X)
IDIST = 1
IOPT  = 0
CALL USPRP (X,N,N1,N2,IDIST,IOPT,WK,IER)
```

Output:


PROBABILITY PLOT FOR NORMAL DISTRIBUTION
.25E+01
.20E+01
.15E+01
.10E+01
.50E+00
.00E+00
-.50E+00
-.10E+01
-.15E+01
-.20E+01
-.25E+01
OBSERVATIONS
.01
.05
.10
.25
.50
.75
.90
.95
.99
CUMULATIVE PROBABILITY

IMSL ROUTINE NAME - USSLF

PURPOSE - PRINT A STEM AND LEAF DISPLAY

USAGE - CALL USSLF (X,N,IUNIT,MAXL)

ARGUMENTS
- X - INPUT VECTOR OF LENGTH N CONTAINING THE DATA TO BE DISPLAYED. ON OUTPUT, X WILL BE SORTED.
- N - THE NUMBER OF OBSERVATIONS IN X. (INPUT)
- IUNIT - SIZE OF THE INCREMENTS ON THE STEM. (INPUT) IF IUNIT IS SET SO SMALL THAT THE LENGTH OF THE STEM IS MORE THAN 60 LINES, USSLF WILL USE AN IUNIT SUCH THAT THE STEM WILL BE NO LONGER THAN 60 LINES. HOWEVER, IF THE USER SPECIFIES IUNIT AS A NEGATIVE INTEGER, USSLF WILL USE THE ABSOLUTE VALUE OF IUNIT, EVEN IF THE STEM WOULD BECOME VERY LONG. IUNIT MUST BE A FACTOR OF 10 OR A MULTIPLE OF 10. A COMMON VALUE FOR IUNIT IS 10.
- MAXL - MAXIMUM DISPLAY WIDTH. (INPUT) MAXL MUST BE 80 OR 129.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UGETIO,VSRTA

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

Algorithm

USSLF prints a stem and leaf display. The user can specify that the plot be longer than 1 page, but the default maximum is 60 lines. The user may also specify a page width of 80 or 129.

A plus (+) at the end of a line indicates that there were too many data points to fit within the width specifications. A scale marked in units of 10 is printed below the stem and leaf display.

See reference:

Tukey, John W., Exploratory Data Analysis, Addison Wesley Publishing Company, Reading, Massachusetts, 1977, Chapter 1.

Example

This example prints a stem and leaf consisting of 27 data points ranging from -21.8 to 106.5.

Input:

```
INTEGER    N,IUNIT,MAXL
REAL       X(27)
X      = (6.0,106.5,34.0,88.1,89.0,0.3,0.7,4.0,4.0,5.0,56.0,62.8,99.0,
          4.0,15.0,76.0,7.6,101.5,33.0,91.0,91.0,-6.3,-21.8,0.0,8.99,
          5.5,6.9)
N      = 27
IUNIT = 10
MAXL   = 80
CALL USSLF (X,N,IUNIT,MAXL)
    :
    :
END
```

Output:

```
    -2 2
    -1
    -0 6
     0 001444566789
     1 5
     2
     3 34
     4
     5 6
     6 3
     7 6
     8 89
     9 119
    10 27
       +---------+---------+
```

IMSL ROUTINE NAME - USTREE

PURPOSE - PRINT A BINARY TREE (WHICH MAY REPRESENT THE OUTPUT OF A CLUSTERING ALGORITHM IN CHAPTER O)

USAGE - CALL USTREE (ND,ICLSON,ICRSON,CLEVEL,IND, XSIM,IOUT,CLVLSK,NCLRST,LEFTRT,STARST,IER)

ARGUMENTS

ND - INPUT NUMBER OF DATA POINTS OR TERMINAL NODES (WHICH MUST BE NUMBERED FROM 1 TO ND). THE ND-1 NON-TERMINAL NODES MUST BE NUMBERED FROM ND+1 TO ND+(ND-1). ND IN THE RANGE 2,3,...,500 IS ALLOWED.

ICLSON - INPUT VECTOR OF LENGTH ND. THE FIRST ND-1 LOCATIONS CONTAIN THE LEFTSON NODES. LOCATION ND IS USED AS WORK STORAGE. NODE NUMBER ND+K HAS LEFTSON NODE GIVEN BY ICLSON(K) AND RIGHTSON NODE GIVEN BY ICRSON(K), FOR K = 1 TO ND-1.

ICRSON - INPUT VECTOR OF RIGHTSON NODES OF LENGTH ND-1. SEE ICLSON DESCRIPTION ABOVE.

CLEVEL - INPUT VECTOR OF LENGTH ND. THE FIRST ND-1 LOCATIONS CONTAIN THE SIMILARITY LEVELS. LOCATION ND IS USED AS WORK STORAGE. NODE ND+K IS PLOTTED ON A VERTICAL SCALE AT THE VALUE CLEVEL(K), FOR K=1 TO ND-1.

IND - INPUT VECTOR OF LENGTH 4. IND(I) CONTAINS WHEN
- I=1, THE HEAD NODE OF THE SUBTREE TO BE PRINTED. MUST BE BETWEEN ND AND 2*ND, EXCLUSIVELY. SEE REMARKS.
- I=2, NUMBER OF PRINTABLE SPACES PER LINE ON THE OUTPUT (PRINTER) DEVICE. IND(2) MUST EXCEED 4.
- I=3, NUMBER OF HORIZONTAL SLICES OF TREE DESIRED TO PROVIDE THE NECESSARY DETAIL. IND(3) MUST BE POSITIVE.
- I=4, NUMBER OF FILLER LINES PRINTED BETWEEN NODE LINES (MUST BE NONNEGATIVE, 1 IS USUALLY SUFFICIENT).

XSIM - INPUT VECTOR OF LENGTH 2 CONTAINING THE INTERVAL ON THE VERTICAL SCALE USED TO PLOT THE TREE (SEE VECTOR CLEVEL). LEVEL XSIM(1) IS WHERE THE TERMINAL NODES (FOR IMSL CLUSTERING ROUTINES, THE DATA POINTS) ARE PRINTED. THE OTHER INTERVAL ENDPOINT XSIM(2) SHOULD INCLUDE THE LEVEL FOR THE HEAD NODE (IND(1)). SEE REMARKS.

IOUT - WORK VECTOR OF LENGTH IND(2)-4.

CLVLSK - WORK VECTOR OF LENGTH ND.

NCLRST - WORK VECTOR OF LENGTH ND.

LEFTRT - WORK VECTOR OF LENGTH ND.

STARST - WORK VECTOR OF LENGTH ND.

IER - ERROR PARAMETER. (OUTPUT)
TERMINAL ERROR
- IER=129 INDICATES ONE OF IND(1), IND(2), IND(3), OR ND WAS INCORRECTLY SPECIFIED.

IER=130 INDICATES A REVERSAL WAS FOUND.
CHECK INPUT ARRAYS. SEE REMARKS.
IER=131 INDICATES ALGORITHM DETECTED
ABNORMALITY PROBABLY DUE TO INCORRECT NODE
NUMBERING.

PRECISION/HARDWARE - SINGLE/ALL

REQD. IMSL ROUTINES - UERTST,UGETIO

NOTATION - INFORMATION ON SPECIAL NOTATION AND
CONVENTIONS IS AVAILABLE IN THE MANUAL
INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS
1. THE TREE MAY BE TOO LARGE TO FIT IN IND(2) SPACES REPRESENTING THE INTERVAL (XSIM(1),XSIM(2)). IF SO, USTREE CAN PRINT THE TREE IN IND(3) SLICES OF THIS INTERVAL WHICH MAY BE CUT AND TAPED TOGETHER.
2. TO PRINT THE ENTIRE TREE FROM IMSL SUBROUTINE OCLINK, THE HEAD NODE IND(1) = ND+(ND-1).
3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.
4. REVERSALS (IER=130) MAY OCCUR IN TWO WAYS. FIRST, TWO NODES MAY BE JOINED AT A LOWER LEVEL (CLOSER TO XSIM(1)). SECOND, THE LEVEL OF THE HEAD NODE MAY LIE ABOVE THE INTERVAL (XSIM(1),XSIM(2)).
5. FOR PROPER DISPLAY, THE TREE CREATED BY USTREE SHOULD BE TURNED TO AN UPRIGHT POSITION.

Algorithm

USTREE prints a binary tree which may represent results of a hierarchical clustering algorithm such as is available via IMSL routine OCLINK.

A binary tree is composed of ND terminal nodes and ND-1 non-terminal nodes uniquely numbered 1 to ND and ND+1 to ND+(ND-1), respectively. Each non-terminal node joins together two "son" nodes which may or may not be terminal. Non-terminal nodes ND+K are printed on the vertical scale interval [XSIM(1),XSIM(2)] at the level given in CLEVEL(K), for K=1,2,...,ND-1.

Example

Input:

```
INTEGER     IOUT(19)      INTEGER form
 or
CHARACTER   IOUT(19)      CHARACTER form

                          IOUT must be typed CHARACTER for certain com-
                          pilers as specified in INTRO Section 5.3.  All
                          other compilers require IOUT to be typed
                          INTEGER.
INTEGER    ND,ICLSON(5),ICRSON(5),IND(4),NCLRST(5),LEFTRT(5),
1          IER
REAL       CLEVEL(5),XSIM(2),CLVLSK(5),STARST(5)
ND      =  5
ICLSON  =  (5,6,4,7,-)
ICRSON  =  (3,1,2,8)
```

```
CLEVEL = (1.,2.,3.,4.,-)
IND    = (9,23,1,0)
XSIM   = (0.0,5.0)
CALL USTREE (ND,ICLSON,ICRSON,CLEVEL,IND,XSIM,IOUT,CLVLSK,NCLRST,
             LEFTRT,STARST,IER)
   :
   :
END
```

Output:

```
IER    =  0


SIMILARITY RANGE FROM      .0000 TO    5.0000

    ++++++++++++++++++++
  5 ****
       6****
  3 ****    *
            7********
  1 ********          *
                      9***
  4 ************    *
                 8****
  2 ************
    ++++++++++++++++++++
```

IMSL ROUTINE NAME - USWBM

PURPOSE - PRINT A MATRIX STORED IN BAND STORAGE MODE.

USAGE - CALL USWBM (ITITLE,NC,A,IA,M,NUC,NLC,WK,IOPT)

ARGUMENTS

ITITLE - A CHARACTER STRING TO PROVIDE A TITLE. (INPUT)
THE LENGTH OF ITITLE MUST NOT EXCEED 20.

NC - LENGTH OF ITITLE. (INPUT)
IF NC.EQ.0 THE TITLE IS NOT PRINTED.

A - THE MATRIX TO BE PRINTED. (INPUT)
A IS STORED IN BAND STORAGE MODE AND HAS DIMENSION M BY (NUC+NLC+1).

IA - ROW DIMENSION OF MATRIX A EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM. (INPUT)

M - NUMBER OF ROWS OF MATRIX A TO BE PRINTED. (INPUT)

NUC - NUMBER OF UPPER CODIAGONALS IN MATRIX A. (INPUT)

NLC - NUMBER OF LOWER CODIAGONALS IN MATRIX A. (INPUT)

WK - WORK AREA VECTOR OF LENGTH M.

IOPT - OPTION INDICATING THE FORMAT STATEMENT TO BE USED. (INPUT)

OPTIONS FOR 129 COLUMNS	OPTIONS FOR 80 COLUMNS	FORMAT
1	2	F18.5
3	4	E15.6
5	6	E25.ISIG

NOTE - ISIG IS INTENDED TO GIVE NEARLY FULL PRECISION REPRESENTATION OF THE MATRIX ELEMENTS. SEE REMARKS SECTION.
IF IOPT IS NOT IN THE RANGE 1 TO 6, 6 IS USED.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS 1. IF AN ASTERISK APPEARS IN THE HIGH ORDER POSITION OF OF THE FIELD, THEN THE NUMBER TO BE PRINTED EXCEEDS THE MAGNITUDE ALLOWED BY THE SELECTED FORMAT.

2. ISIG IS DEFINED TO BE THE NUMBER OF DIGITS IN DECIMAL CONSTANTS. MORE SPECIFICALLY,

ISIG	PRECISION	HARDWARE
7	SINGLE	H32
16	DOUBLE	H32
9	SINGLE	H36
11	SINGLE	H48
14	SINGLE	H60

3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USWBM prints M rows and M columns of a band matrix, A, stored in band storage mode, with E-format or F-format, for an 80 or 129 column printer. A is printed as a full square matrix.

The matrix A (with zeros inserted) is printed with the rows and columns numbered. One of six format statements can be used. (See IOPT in the argument description.)

Example

This example prints a matrix A (stored in band mode as a 4 by 3 matrix) as a 4 by 4 full matrix using a F18.5 format for a 129 column printer. (IOPT=1)

Input:

```
INTEGER   NC,IA,M,NUC,NLC,IOPT
REAL      A(4,3),WK(4)
NC    =   10
```

$$A = \begin{bmatrix} 0. & 1.1234 & 2.1234 \\ 5.1234 & 6.1234 & 7.1234 \\ 10.1234 & 11.1234 & 12.1234 \\ 15.1234 & 16.1234 & 0. \end{bmatrix}$$

band storage mode

```
IA    =   4
M     =   4
NUC   =   1
NLC   =   1
IOPT  =   1
   CALL USWBM (10HUSWBM TEST,NC,A,IA,M,NUC,NLC,WK,IOPT)   HOLLERITH form
or CALL USWBM ('USWBM TEST',NC,A,IA,M,NUC,NLC,WK,IOPT)    CHARACTER form
                                                          See INTRO Section
   :                                                      5.3 for details
   :
END
```

Output:

```
USWBM TEST
                1           2           3           4
  1          1.12340     2.12340      .00000      .00000
  2          5.12340     6.12340     7.12340      .00000
  3           .00000    10.12340    11.12340    12.12340
  4           .00000      .00000    15.12340    16.12340
```

IMSL ROUTINE NAME - USWBS

PURPOSE - PRINT A MATRIX STORED IN BAND SYMMETRIC STORAGE MODE.

USAGE - CALL USWBS (ITITLE,NC,A,IA,M,NLC,WK,IOPT)

ARGUMENTS

ITITLE - A CHARACTER STRING TO PROVIDE A TITLE. (INPUT) THE LENGTH OF ITITLE MUST NOT EXCEED 20.

NC - LENGTH OF ITITLE. (INPUT) IF NC.EQ.0 THE TITLE IS NOT PRINTED.

A - THE MATRIX TO BE PRINTED. (INPUT) A IS STORED IN BAND SYMMETRIC STORAGE MODE AND HAS DIMENSION M BY (2*NLC)+1.

IA - ROW DIMENSION OF MATRIX A EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM. (INPUT)

M - NUMBER OF ROWS OF MATRIX A TO BE PRINTED. (INPUT)

NLC - NUMBER OF UPPER OR LOWER CODIAGONALS IN MATRIX A. (INPUT)

WK - WORK AREA VECTOR OF LENGTH M.

IOPT - OPTION INDICATING THE FORMAT STATEMENT TO BE USED. (INPUT)

OPTIONS FOR 129 COLUMNS	OPTIONS FOR 80 COLUMNS	FORMAT
1	2	F18.5
3	4	E15.6
5	6	E25.ISIG

NOTE - ISIG IS INTENDED TO GIVE NEARLY FULL PRECISION REPRESENTATION OF THE MATRIX ELEMENTS. SEE REMARKS SECTION.
IF IOPT IS NOT IN THE RANGE 1 TO 6, 6 IS USED.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS 1. IF AN ASTERISK APPEARS IN THE HIGH ORDER POSITION OF OF THE FIELD, THEN THE NUMBER TO BE PRINTED EXCEEDS THE MAGNITUDE ALLOWED BY THE SELECTED FORMAT.

2. ISIG IS DEFINED TO BE THE NUMBER OF DIGITS IN DECIMAL CONSTANTS. MORE SPECIFICALLY,

ISIG	PRECISION	HARDWARE
7	SINGLE	H32
16	DOUBLE	H32
9	SINGLE	H36
11	SINGLE	H48
14	SINGLE	H60

3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USWBS prints the lower triangular portion of a band symmetric matrix, A, (which is stored in band symmetric mode), with E-format or F-format for an 80 or 129 column printer.

The matrix A (with zeros inserted) is printed with the rows and columns numbered. One of six format statements can be used. (See IOPT in the argument description.)

Example

This example prints the lower triangular portion of a matrix A (stored in band symmetric mode as a 7 by 3 matrix) using an F18.5 format for an 80 column printer. (IOPT=2)

Input:

```
INTEGER   NC,IA,M,NLC,IOPT
REAL      A(7,3),WK(7)
NC    =   10
```

```
          [ 0.   0.   1. ]
          [ 0.   2.   2. ]
          [ 3.   3.   3. ]
A     =   [ 4.   4.   4. ]      band symmetric storage mode
          [ 5.   5.   5. ]
          [ 6.   6.   6. ]
          [ 7.   7.   7. ]
```

```
IA    =   7
M     =   7
NLC   =   2
IOPT  =   2
   CALL USWBS (10HUSWBS TEST,NC,A,IA,M,NLC,WK,IOPT)   { HOLLERITH form
or CALL USWBS ('USWBS TEST',NC,A,IA,M,NLC,WK,IOPT)    { CHARACTER form
   :                                                  { See INTRO Section
   :                                                  { 5.3 for details
END
```

Output:

USWBS TEST

	1 4 7	2 5	3 6
1	1.00000		
2	2.00000	2.00000	
3	3.00000	3.00000	3.00000
4	.00000 4.00000	4.00000	4.00000
5	.00000 5.00000	.00000 5.00000	5.00000
6	.00000 6.00000	.00000 6.00000	.00000 6.00000
7	.00000 .00000 7.00000	.00000 7.00000	.00000 7.00000

IMSL ROUTINE NAME - USWCH

PURPOSE - PRINT A COMPLEX HERMITIAN MATRIX STORED IN HERMITIAN STORAGE MODE

USAGE - CALL USWCH (ITITLE,NC,A,M,IOPT)

ARGUMENTS

ITITLE - A CHARACTER STRING TO PROVIDE A TITLE. (INPUT) THE LENGTH OF ITITLE MUST NOT EXCEED 20.

NC - LENGTH OF ITITLE. (INPUT) IF NC.EQ.0 THE TITLE IS NOT PRINTED.

A - COMPLEX MATRIX TO BE PRINTED. (INPUT)

M - NUMBER OF ROWS (OR COLUMNS) OF MATRIX A TO BE PRINTED. (INPUT)

IOPT - OPTION INDICATING THE FORMAT STATEMENT TO BE USED. (INPUT)

OPTIONS FOR 129 COLUMNS	OPTIONS FOR 80 COLUMNS	FORMAT
1	2	F12.4
3	4	E12.4
5	6	E25.ISIG

NOTE - ISIG IS INTENDED TO GIVE NEARLY FULL PRECISION REPRESENTATION OF THE MATRIX ELEMENTS. SEE REMARKS SECTION.
IF IOPT IS NOT IN THE RANGE 1 TO 6, 6 IS USED.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS

1. IF AN ASTERISK APPEARS IN THE HIGH ORDER POSITION OF THE FIELD, THEN THE NUMBER TO BE PRINTED EXCEEDS THE MAGNITUDE ALLOWED BY THE SELECTED FORMAT.
2. ISIG IS DEFINED TO BE THE NUMBER OF DIGITS IN DECIMAL CONSTANTS. MORE SPECIFICALLY,

ISIG	PRECISION	HARDWARE
7	SINGLE	H32
16	DOUBLE	H32
9	SINGLE	H36
11	SINGLE	H48
14	SINGLE	H60

3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USWCH prints the lower triangular portion of an M by M complex Hermitian matrix (which is stored in Hermitian mode), with E-format or F-format for an 80 or 129 column printer.

The matrix A is printed with the rows and columns numbered. One of six format statements can be used. (See IOPT in the argument description.)

Example

This example prints the lower triangular portion of a 4 by 4 complex Hermitian matrix A using an E12.4 format for an 80 column printer (IOPT=4).

Input:

```
INTEGER   NC,M,IOPT
COMPLEX   A(10)
NC    =    10
M     =     4
IOPT  =     4

  (( 1.1234, 2.1234)( 3.1234, 4.1234)( 5.1234, 6.1234)( 7.1234, 8.1234)
A=( 9.1234,10.1234)(11.1234,12.1234)(13.1234,14.1234)(15.1234,16.1234)
  (17.1234,18.1234)(19.1234,20.1234))

   CALL USWCH(10HUSWCH TEST,NC,A,M,IOPT)   {HOLLERITH form
or CALL USWCH('USWCH TEST',NC,A,M,IOPT)    {CHARACTER form
                                           {See INTRO Section 5.3
                                           {for details
  :
  :
END
```

Output:

```
USWCH TEST

                  1                                   2
                  3                                   4

  1 (   .1123E 01,   .2123E 01)

  2 (   .3123E 01,   .4123E 01)  (   .5123E 01,   .6123E 01)

  3 (   .7123E 01,   .8123E 01)  (   .9123E 01,   .1012E 02)
    (   .1112E 02,   .1212E 02)

  4 (   .1312E 02,   .1412E 02)  (   .1512E 02,   .1612E 02)
    (   .1712E 02,   .1812E 02)  (   .1912E 02,   .2012E 02)
```

IMSL ROUTINE NAME - USWCM

PURPOSE - PRINT A COMPLEX MATRIX STORED IN FULL STORAGE MODE

USAGE - CALL USWCM (ITITLE,NC,A,IA,N,M,IOPT)

ARGUMENTS

ITITLE - A CHARACTER STRING TO PROVIDE A TITLE. (INPUT) THE LENGTH OF ITITLE MUST NOT EXCEED 20.

NC - LENGTH OF ITITLE. (INPUT) IF NC.EQ.0 THE TITLE IS NOT PRINTED.

A - COMPLEX MATRIX TO BE PRINTED. (INPUT)

IA - ROW DIMENSION OF MATRIX A EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM. (INPUT)

N - NUMBER OF ROWS OF MATRIX A TO BE PRINTED. (INPUT)

M - NUMBER OF COLUMNS OF MATRIX A TO BE PRINTED. (INPUT)

IOPT - OPTION INDICATING THE FORMAT STATEMENT TO BE USED. (INPUT)

OPTIONS FOR 129 COLUMNS	OPTIONS FOR 80 COLUMNS	FORMAT
1	2	F12.4
3	4	E12.4
5	6	E25.ISIG

NOTE - ISIG IS INTENDED TO GIVE NEARLY FULL PRECISION REPRESENTATION OF THE MATRIX ELEMENTS. SEE REMARKS SECTION.
IF IOPT IS NOT IN THE RANGE 1 TO 6, 6 IS USED.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS

1. IF AN ASTERISK APPEARS IN THE HIGH ORDER POSITION OF THE FIELD, THEN THE NUMBER TO BE PRINTED EXCEEDS THE MAGNITUDE ALLOWED BY THE SELECTED FORMAT.
2. ISIG IS DEFINED TO BE THE NUMBER OF DIGITS IN DECIMAL CONSTANTS. MORE SPECIFICALLY,

ISIG	PRECISION	HARDWARE
7	SINGLE	H32
16	DOUBLE	H32
9	SINGLE	H36
11	SINGLE	H48
14	SINGLE	H60

3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USWCM prints N rows and M columns of a complex matrix, A, with E-format or F-format for an 80 or 129 column printer.

The matrix A is printed with the rows and columns numbered. One of six format statements can be used. (See IOPT argument description.)

Example

This example prints a 3 by 4 complex matrix A using an E12.4 format for an 80 column printer (IOPT=4).

Input:

```
INTEGER   NC,IA,N,M,IOPT
COMPLEX   A(3,4)
NC    =     10
IA    =      3
N     =      3
M     =      4
IOPT  =      4

  (( 1.1234, 2.1234)( 3.1234, 4.1234)( 5.1234, 6.1234)( 7.1234, 8.1234)
A=( 9.1234,10.1234)(11.1234,12.1234)(13.1234,14.1234)(15.1234,16.1234)
  (17.1234,18.1234)(19.1234,20.1234)(21.1234,22.1234)(23.1234,24.1234))

   CALL USWCM(10HUSWCM TEST,NC,A,IA,N,M,IOPT)   { HOLLERITH form
or CALL USWCM('USWCM TEST',NC,A,IA,N,M,IOPT)    { CHARACTER form
                                                { See INTRO Section 5.3
                                                { for details
  .
  .
  .
END
```

Output:

```
USWCM TEST

                    1                                   2
                    3                                   4

  1 (    .1123E 01,    .2123E 01)   (    .3123E 01,    .4123E 01)
    (    .5123E 01,    .6123E 01)   (    .7123E 01,    .8123E 01)

  2 (    .9123E 01,    .1012E 02)   (    .1112E 02,    .1212E 02)
    (    .1312E 02,    .1412E 02)   (    .1512E 02,    .1612E 02)

  3 (    .1712E 02,    .1812E 02)   (    .1912E 02,    .2012E 02)
    (    .2112E 02,    .2212E 02)   (    .2312E 02,    .2412E 02)
```

IMSL ROUTINE NAME - USWCV

PURPOSE - PRINT A COMPLEX VECTOR

USAGE - CALL USWCV (ITITLE,NC,A,M,INC,IOPT)

ARGUMENTS

ITITLE - A CHARACTER STRING TO PROVIDE A TITLE. (INPUT)
THE LENGTH OF ITITLE MUST NOT EXCEED 20.

NC - LENGTH OF ITITLE. (INPUT)
IF NC.EQ.0 THE TITLE IS NOT PRINTED.

A - COMPLEX VECTOR TO BE PRINTED. (INPUT)

M - NUMBER OF ELEMENTS OF VECTOR A TO BE PRINTED. (INPUT)

INC - DISPLACEMENT BETWEEN ELEMENTS OF THE VECTOR TO BE PRINTED. (INPUT) USWCV PRINTS A(1+(I-1)*INC) FOR I=1,...,M. SEE REMARKS.

IOPT - OPTION INDICATING THE FORMAT STATEMENT TO BE USED. (INPUT)

OPTIONS FOR 129 COLUMNS	OPTIONS FOR 80 COLUMNS	FORMAT
1	2	F12.4
3	4	E12.4
5	6	E25.ISIG

NOTE - ISIG IS INTENDED TO GIVE NEARLY FULL PRECISION REPRESENTATION OF THE MATRIX ELEMENTS. SEE REMARKS SECTION.
IF IOPT IS NOT IN THE RANGE 1 TO 6, 6 IS USED.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS

1. IF AN ASTERISK APPEARS IN THE HIGH ORDER POSITION OF OF THE FIELD, THEN THE NUMBER TO BE PRINTED EXCEEDS THE MAGNITUDE ALLOWED BY THE SELECTED FORMAT.
2. ISIG IS DEFINED TO BE THE NUMBER OF DIGITS IN DECIMAL CONSTANTS. MORE SPECIFICALLY,

ISIG	PRECISION	HARDWARE
7	SINGLE	H32
16	DOUBLE	H32
9	SINGLE	H36
11	SINGLE	H48
14	SINGLE	H60

3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.
4. IF A IS A 1-DIMENSIONAL ARRAY, THEN INC=1. FORTRAN STORES MATRICES COLUMN WISE. HENCE, IF A IS A 2-DIMENSIONAL ARRAY AND A ROW OF A IS TO BE PRINTED, INC= THE ROW DIMENSION OF A EXACTLY AS SPECIFIED IN THE CALLING PROGRAM. IF A IS A 2-DIMENSIONAL ARRAY AND A COLUMN OF A IS TO BE PRINTED, INC=1.

Algorithm

USWCV prints M components of a vector A with E-format or F-format for an 80 or 129 column printer.

The vector A, which may require more than one line, is printed according to one of six format statements. (See IOPT in the argument description.)

Example

This example prints a seven element vector A using an E12.4 format for an 80 column printer. (IOPT=4)

Input:

```
INTEGER   NC,M,INC,IOPT
COMPLEX   A(7)
NC    =     10

      (( 1.1234, 2.1234)(3.1234, 4.1234)( 5.1234, 6.1234)
A     = ( 7.1234, 8.1234)(9.1234,10.1234)(11.1234,12.1234)
        (13.1234,14.1234))

M     =      7
INC   =      1
IOPT  =      4
   CALL USWCV(10HUSWCV TEST,NC,A,M,INC,IOPT)   {HOLLERITH form
or CALL USWCV('USWCV TEST',NC,A,M,INC,IOPT)    {CHARACTER form
                                               {See INTRO Section 5.3
                                               {for details
  .
  .
  .
END
```

Output:

```
USWCV TEST

     (    .1123E 01,    .2123E 01)  (    .3123E 01,    .4123E 01)
     (    .5123E 01,    .6123E 01)  (    .7123E 01,    .8123E 01)
     (    .9123E 01,    .1012E 02)  (    .1112E 02,    .1212E 02)
     (    .1312E 02,    .1412E 02)
```

IMSL ROUTINE NAME - USWFM

PURPOSE - PRINT A MATRIX STORED IN FULL STORAGE MODE.

USAGE - CALL USWFM (ITITLE,NC,A,IA,N,M,IOPT)

ARGUMENTS

ITITLE - A CHARACTER STRING TO PROVIDE A TITLE. (INPUT)
THE LENGTH OF ITITLE MUST NOT EXCEED 20.

NC - LENGTH OF ITITLE. (INPUT)
IF NC.EQ.0 THE TITLE IS NOT PRINTED.

A - NAME OF THE MATRIX TO BE PRINTED. (INPUT)

IA - ROW DIMENSION OF MATRIX A EXACTLY AS SPECIFIED IN THE DIMENSION STATEMENT IN THE CALLING PROGRAM. (INPUT)

N - NUMBER OF ROWS OF MATRIX A TO BE PRINTED. (INPUT)

M - NUMBER OF COLUMNS OF MATRIX A TO BE PRINTED. (INPUT)

IOPT - OPTION INDICATING THE FORMAT STATEMENT TO BE USED. (INPUT)

OPTIONS FOR 129 COLUMNS	OPTIONS FOR 80 COLUMNS	FORMAT
1	2	F18.5
3	4	E15.6
5	6	E25.ISIG

NOTE - ISIG IS INTENDED TO GIVE NEARLY FULL PRECISION REPRESENTATION OF THE MATRIX ELEMENTS. SEE REMARKS SECTION.
IF IOPT IS NOT IN THE RANGE 1 TO 6, 6 IS USED.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS

1. IF AN ASTERISK APPEARS IN THE HIGH ORDER POSITION OF OF THE FIELD, THEN THE NUMBER TO BE PRINTED EXCEEDS THE MAGNITUDE ALLOWED BY THE SELECTED FORMAT.
2. ISIG IS DEFINED TO BE THE NUMBER OF DIGITS IN DECIMAL CONSTANTS. MORE SPECIFICALLY,

ISIG	PRECISION	HARDWARE
7	SINGLE	H32
16	DOUBLE	H32
9	SINGLE	H36
11	SINGLE	H48
14	SINGLE	H60

3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USWFM prints N rows and M columns of a matrix, A, with E-format or F-format for an 80 or 129 column printer.

The matrix A is printed with the rows and columns numbered. One of six format statements can be used. (See IOPT argument description.)

Example

This example prints a 3 by 4 matrix A using a F18.5 format for an 80 column printer (IOPT=2).

Input:

```
INTEGER  NC,IA,N,M,IOPT
REAL     A(3,4)
NC   =  10
IA   =  3
N    =  3
M    =  4
IOPT =  2
```

$$A = \begin{bmatrix} 1.1234 & 2.1234 & 3.1234 & 4.1234 \\ 5.1234 & 6.1234 & 7.1234 & 8.1234 \\ 9.1234 & 10.1234 & 11.1234 & 12.1234 \end{bmatrix}$$

```
   CALL USWFM (10HUSWFM TEST,NC,A,IA,N,M,IOPT)   { HOLLERITH form
or CALL USWFM ('USWFM TEST,NC,A,IA,N,M,IOPT)     { CHARACTER form
   :                                             { See INTRO Section 5.3
   :                                             { for details
END
```

Output:

```
USWFM TEST

                1              2              3
                4

  1         1.12340        2.12340        3.12340
            4.12340

  2         5.12340        6.12340        7.12340
            8.12340

  3         9.12340       10.12340       11.12340
           12.12340
```

IMSL ROUTINE NAME - USWFV

PURPOSE - PRINT A VECTOR.

USAGE - CALL USWFV (ITITLE,NC,A,M,INC,IOPT)

ARGUMENTS

ITITLE - A CHARACTER STRING TO PROVIDE A TITLE. (INPUT)
THE LENGTH OF ITITLE MUST NOT EXCEED 20.

NC - LENGTH OF ITITLE. (INPUT)
IF NC.EQ.0 THE TITLE IS NOT PRINTED.

A - THE VECTOR TO BE PRINTED. (INPUT)

M - NUMBER OF ELEMENTS OF VECTOR A TO BE PRINTED. (INPUT)

INC - DISPLACEMENT BETWEEN ELEMENTS OF THE VECTOR TO BE PRINTED. (INPUT) USWFV PRINTS A(1+(I-1)*INC) FOR I=1,...,M. SEE REMARKS.

IOPT - OPTION INDICATING THE FORMAT STATEMENT TO BE USED. (INPUT)

OPTIONS FOR 129 COLUMNS	OPTIONS FOR 80 COLUMNS	FORMAT
1	2	F18.5
3	4	E15.6
5	6	E25.ISIG

NOTE - ISIG IS INTENDED TO GIVE NEARLY FULL PRECISION REPRESENTATION OF THE MATRIX ELEMENTS. SEE REMARKS SECTION.
IF IOPT IS NOT IN THE RANGE 1 TO 6, 6 IS USED.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS 1. IF AN ASTERISK APPEARS IN THE HIGH ORDER POSITION OF OF THE FIELD, THEN THE NUMBER TO BE PRINTED EXCEEDS THE MAGNITUDE ALLOWED BY THE SELECTED FORMAT.

2. ISIG IS DEFINED TO BE THE NUMBER OF DIGITS IN DECIMAL CONSTANTS. MORE SPECIFICALLY,

ISIG	PRECISION	HARDWARE
7	SINGLE	H32
16	DOUBLE	H32
9	SINGLE	H36
11	SINGLE	H48
14	SINGLE	H60

3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.
4. IF A IS A 1-DIMENSIONAL ARRAY, THEN INC=1. FORTRAN STORES MATRICES COLUMNWISE. HENCE, IF A IS A 2-DIMENSIONAL ARRAY AND A ROW OF A IS TO BE PRINTED, INC= THE ROW DIMENSION OF A EXACTLY AS SPECIFIED IN THE CALLING PROGRAM. IF A IS A 2-DIMENSIONAL ARRAY AND A COLUMN OF A IS TO BE PRINTED, INC=1.

Algorithm

USWFV prints M components of a vector A with E-format or F-format for an 80 or 129 column printer.

The vector A, which may require more than one line is printed according to one of six format statements. (See IOPT in the argument description.)

Example

This example prints a twelve element vector A using an F18.5 format for an 80 column printer. (IOPT=2)

Input:

```
INTEGER   NC,M,INC,IOPT
REAL      A(12)
NC    =  10
A     = (1.123456,2.123456,3.123456,4.123456,5.123456,6.123456,7.123456,
         8.123456,9.123456,10.123456,11.123456,12.123456)
M     =  12
INC   =  1
IOPT  =  2
   CALL USWFV (10HUSWFV TEST,NC,A,M,INC,IOPT)   { HOLLERITH form
or CALL USWFV ('USWFV TEST',NC,A,M,INC,IOPT)    { CHARACTER form
   :                                            { See INTRO Section 5.3
   :                                            { for details
END
```

Output:

USWFV TEST

1.12346	2.12346	3.12346
4.12346	5.12346	6.12346
7.12346	8.12346	9.12346
10.12346	11.12346	12.12346

IMSL ROUTINE NAME - USWSM

PURPOSE - PRINT A MATRIX STORED IN SYMMETRIC STORAGE MODE.

USAGE - CALL USWSM (ITITLE,NC,A,M,IOPT)

ARGUMENTS

ITITLE - A CHARACTER STRING TO PROVIDE A TITLE. (INPUT) THE LENGTH OF ITITLE MUST NOT EXCEED 20.

NC - LENGTH OF ITITLE. (INPUT) IF NC.EQ.0 THE TITLE IS NOT PRINTED.

A - NAME OF THE MATRIX TO BE PRINTED. (INPUT)

M - NUMBER OF ROWS (OR COLUMNS) OF MATRIX A TO BE PRINTED. (INPUT)

IOPT - OPTION INDICATING THE FORMAT STATEMENT TO BE USED. (INPUT)

OPTIONS FOR 129 COLUMNS	OPTIONS FOR 80 COLUMNS	FORMAT
1	2	F18.5
3	4	E15.6
5	6	E25.ISIG

NOTE - ISIG IS INTENDED TO GIVE NEARLY FULL PRECISION REPRESENTATION OF THE MATRIX ELEMENTS. SEE REMARKS SECTION.
IF IOPT IS NOT IN THE RANGE 1 TO 6, 6 IS USED.

PRECISION/HARDWARE - SINGLE AND DOUBLE/H32
- SINGLE/H36,H48,H60

REQD. IMSL ROUTINES - UGETIO,USPKD

NOTATION - INFORMATION ON SPECIAL NOTATION AND CONVENTIONS IS AVAILABLE IN THE MANUAL INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS

1. IF AN ASTERISK APPEARS IN THE HIGH ORDER POSITION OF OF THE FIELD, THEN THE NUMBER TO BE PRINTED EXCEEDS THE MAGNITUDE ALLOWED BY THE SELECTED FORMAT.
2. ISIG IS DEFINED TO BE THE NUMBER OF DIGITS IN DECIMAL CONSTANTS. MORE SPECIFICALLY,

ISIG	PRECISION	HARDWARE
7	SINGLE	H32
16	DOUBLE	H32
9	SINGLE	H36
11	SINGLE	H48
14	SINGLE	H60

3. OUTPUT IS WRITTEN TO THE UNIT SPECIFIED BY IMSL ROUTINE UGETIO. SEE THE UGETIO DOCUMENT FOR DETAILS.

Algorithm

USWSM prints the lower triangular portion of an M by M symmetric matrix, A (which is stored in symmetric mode), with E-format or F-format for an 80 or 129 column printer.

The matrix A is printed with the rows and columns numbered. One of six format statements can be used. (See IOPT in the argument description.)

Example

This example prints the lower triangular portion of a 7 by 7 symmetrically stored matrix A using an E15.6 format for an 80 column printer (IOPT=4).

Input:

```
INTEGER  NC,M,IOPT
REAL     A(28)
NC    =  10
M     =  7
IOPT  =  4
A     = (1.,2.,3.,4.,5.,6.,7.,8.,9.,10.,11.,12.,13.,14.,15.,16.,17.,18.,
         19.,20.,21.,22.,23.,24.,25.,26.,27.,28.)
   CALL USWSM (10HUSWSM TEST,NC,A,M,IOPT)  {HOLLERITH form
or CALL USWSM ('USWSM TEST',NC,A,M,IOPT)   {CHARACTER form
   :                                       {See INTRO Section 5.3 for
   .                                       {details
END
```

Output:

```
USWSM TEST
          1             2             3             4             5
          6             7

 1   .100000E 01

 2   .200000E 01   .300000E 01

 3   .400000E 01   .500000E 01   .600000E 01

 4   .700000E 01   .800000E 01   .900000E 01   .100000E 02

 5   .110000E 02   .120000E 02   .130000E 02   .140000E 02   .150000E 02

 6   .160000E 02   .170000E 02   .180000E 02   .190000E 02   .200000E 02
     .210000E 02

 7   .220000E 02   .230000E 02   .240000E 02   .250000E 02   .260000E 02
     .270000E 02   .280000E 02
```