# TEMPROB: *A FORTRAN IV PROGRAM FOR CALCULATING TEMPERATURE PROBABILITIES FROM EXTREME MINIMUM TEMPERATURE DATA*

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Texas Agricultural Market Research
and Development Center
Texas A&M University
College Station, Texas

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# TEMPROB: *A FORTRAN IV PROGRAM FOR CALCULATING TEMPERATURE PROBABILITIES FROM EXTREME MINIMUM TEMPERATURE DATA*

Thomas L. Sporleder*

## INTRODUCTION

A fundamental challenge concomitant with the marketing success of any firm is attainment of the ability to supply the market with a predetermined quantity of a consistent quality product. In the agricultural industries particularly, this ability may depend upon favorable weather conditions. Weather constitutes an exogenous factor which may influence quantity produced, quality of the product marketed, and consequently prices received (or paid) for every firm associated with a commodity system.[1] Specifically, many firms involved with the production and/or marketing of fruit and vegetable crops must consider alternative eventualities that may be caused by freezing temperatures. Managers of such firms, at best, can formulate plans for the future given their subjective expectations

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*Assistant Professor, Department of Agricultural Economics, Texas A&M University.

[1]For the concept of a commodity system and commodity system interaction consult [1].

concerning freeze loss or damage eventualities relevant to their firm.

The two types of outcomes or eventualities which influence plans for the future of every business firm are risk and uncertainty. These two types may be contrasted by defining risk as "...variability or outcomes which are measurable in an empirical manner" while uncertainty refers to outcomes which cannot be established empirically [4, pp. 440-443]. In the context of freezes, freeze damage or loss to a particular commodity is an uncertainty while the occurrence of a particular temperature is a risk.[2] Thus, the manager of a firm may consider the probability of low temperatures occurring in the relevant geographic location and, in addition to other information, arrive at some subjective expectation about potential commodity damage or loss from a freeze. Calculating probabilities of low temperature occurrence in the relevant geographic area represents a logical prerequisite to formulating a subjective expectation with respect to potential crop damage or loss from freezes. A computer program, TEMPROB, was specifically designed to provide objective information concerning the probability of low temperature occurrence for a particular

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[2]This is because actual freeze damage or loss to a crop is a function of variables other than temperature which possess probabilities which are extremely difficult to quantify. For a discussion of some micrometeorlogical and physiological variables which may influence freeze damage, particularly in citrus, see [7,9].

geographic region.[3]

GENERAL DESCRIPTION

TEMPROB is a special purpose multipartite design FORTRAN IV computer program compatible with WATFOR on an IBM 360/65 to compute temperature probabilities and related statistics from extreme minimum temperature data. TEMPROB utilizes Lieblein's fitting procedure for extreme value data to estimate the parameters of the Fisher-Tippett Type I distribution.

The cummulative distribution function (cdf) of the Fisher-Tippett Type I extreme minimum value function is given by:

$$(1) \qquad P(x) = 1 - \exp\left[ - e^{-(x - \alpha)/\beta} \right]$$

where $\beta < 0$, $-\infty < \alpha < \infty$, $-\infty < x < \infty$, and x is some particular temperature.

The parameters $\alpha$ and $\beta$ of the cdf are computed by Lieblein's fitting procedure with weights in Lieblein's estimator for subgroup size 10 [6]. Parameters estimated by Lieblein's procedure are "unbiased and efficient as possible."[4] TEMPROB computes the reduced variate of the cdf for each temperature throughout the range of the extreme minimum temperature data.

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[3] TEMPROB is an acronym for temperature probability.

[4] For further explanation of Lieblein's procedure and tables of weights in Lieblein's estimator see [2, pp. 21-23 and 223-226]. Weights for subgroup size 10 utilized in TEMPROB were obtained from C. K. Vestal, Regional Climatologist, Weather Bureau, Fort Worth, Texas.

In addition to the value of the reduced variate over the range of the data, TEMPROB computes the return period $T(x)$ for each random variate over the range. A return period is defined as the average time distance between successive rare events, each one of which is at least as small as the first [8, p. 3]. More precisely, let $P(x_o)$ be the probability that temperature x will occur which is less than or equal to a chosen temperature $x_o$. Then

(2) $$P(x_o) = 1 - F(x_o),$$

where

(3) $$F(x_o) = \exp\left[ - e^{-(x_o - \alpha)/\beta} \right]$$

and the return period for $x_o$ is

(4) $$T(x_o) = 1 / P(x_o).$$

Thus, $T(x_o)$ is the number of time periods which will elapse, on the average, before a temperature equal to or less than $x_o$ will occur. The return period statistics computed by TEMPROB are always in terms of years.

In addition to $P(x_o)$, TEMPROB computes $F(x_o)$ and $W(v)$. The probability that temperature x will exceed $x_o$ is given by $F(x_o)$. $W(v)$ is the probability that a temperature x such that $x = x_o$ will occur at least once within v years. This probability is defined as:

(5) $$W(v) = 1 - [\ F(x_o)\ ]^v$$

and is uniquely related to the return period by:

(6) $$W(v) = 1 - [\ 1 - (1\ /\ T(x_o))\ ]^v.$$

Also, note that if $v = 1$ then:

(7) $$W(v) = P.$$

Statistical Aspects

This section introduces the reader to generalized statistical relationships among the Fisher-Tippett Type I density and distribution functions and the computational methods employed in calculating temperature probabilities. A TEMPROB user not interested in these more basic relationships may skip this section and still be able to use and interpret output from the program.

The Fisher-Tippett Type I extreme value function has two forms depending upon whether maximum or minimum values are under consideration. When the data consist of extreme maximum observations (such as rainfall or temperature) the probability density function (pdf) is [3, pp. 111-119]:

(8) $$f_1(x,\ \alpha,\ \beta) = \frac{1}{\beta} \exp[\ -\frac{1}{\beta}\ (x - \alpha) - e^{-\ (x\ -\ \alpha)/\beta}\ ]$$

where $-\infty < x < \infty$, $-\infty < \alpha < \infty$ and $\beta > 0$. The cumulative distribution function (cdf) for maximum elements is:

(9) $$G_1(x) = \int_{-\infty}^{x} f_1(x,\ \alpha,\ \beta)dx = \exp[\ -\ e^{-\ (x\ -\ \alpha)/\beta}\ ]$$

When the data are minimum values the pdf is:

(10) $$f_2(x, \alpha, \beta_1) = \frac{1}{\beta_1} \exp[ \frac{1}{\beta_1} (x - \alpha) - e^{(x - \alpha)/\beta_1} ]$$

where $- \infty < x < \infty$, $- \infty < \alpha < \infty$, and $\beta_1 > 0$. The corresponding cdf is:

(11) $$G_2(x) = \int_{-\infty}^{x} f_2(x, \alpha, \beta_1)dx = 1 - \exp[ - e^{(x - \alpha)/\beta_1} ]$$

Since TEMPROB is specifically designed for extreme minimum temperature data (10) and (11) are the appropriate density and distribution functions, respectively. However, note that $G_1(x)$ and $G_2(x)$ are related. The reduced variate $z = (x - \alpha)/\beta$ may be used to rewrite $G_1(x)$ and $G_2(x)$ as:

(12) $$G_1(z) = \exp[ - e^{- z} ]$$

and

(13) $$G_2(z) = 1 - \exp[ - e^{z} ] = 1 - G_1( - z ).$$

Some confusion may arise from the $\beta$ parameter of the maximum and minimum density functions. Lieblein's fitting procedure (specifically Lieblein's weights) assures that $\beta > 0$ in (8). However, when the distribution function for minimum values (11) is under consideration, Lieblein's procedure does not estimate $\beta_1$ but $\beta_2 < 0$ where $\beta_1 = - \beta_2$. Thus, the pdf for minimum values, when Lieblein's fitting procedure is employed, may be written as:

$$(14) \quad f_2(x, \alpha, \beta_2) = -\frac{1}{\beta_2} \exp[ -\frac{1}{\beta_2} (x - \alpha) - e^{-(x - \alpha)/\beta_2} ]$$

where $-\infty < x < \infty$, $-\infty < \alpha < \infty$, and $\beta_2 < 0$. Note the similarity between (8) and (14). The prime difference between the pdf for minimum and maximum values is that the $\beta$ parameters are of opposite sign. If $\beta_2$ is mistakenly taken to be positive then (14) is always negative; hence, its properties would not conform to those of a density function.[5]

The cdf corresponding to (14) is:

$$(15) \quad G_2(x) = \int_{-\infty}^{x} f_2 (x, \alpha, \beta_2)dx = 1 - \exp[ - e^{-(x - \alpha)/\beta_2} ]$$

where $\beta_2 < 0$.

If

$$(16) \quad F(x) = \exp[ - e^{-(x - \alpha)/\beta_2} ] = \int_{x}^{\infty} f_2(x, \alpha, \beta_2)dx$$

then

$$(17) \quad G_2(x) = 1 - F(x).$$

Once again deceptive similarity exists; this time between (9) and (16). As with the density functions, the prime difference is $\beta_2 < 0$ in (16).

The sometimes subtle differences in the maximum and minimum formulae above are especially important when temperature probabil-

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[5]The properties of density functions are given in [5, pp. 16-17].

ities are considered since the common climatological custom is to utilize a function of the form:

$$F(x) = \exp[\,-\,e^{-(x-\alpha)/\beta_2}\,] \tag{18}$$

where $\beta_2 < 0$. Thus, TEMPROB conventions follow this latter custom. However, in addition to (18), particular values of the cdf, (15), are computed by TEMPROB and denoted by P(x).

Input

TEMPROB is designed for chronologically ordered monthly extreme minimum temperature input data. Let N be the number of annual observations, then restrictions on N are that N/10 must be an integer value and $N \leq 70$. In other words, the number of annual observations permissible must be in multiples of 10. This restriction is in part a statistical one and arises from the use of the Lieblein fitting procedure [2, p. 225]. Also for statistical reasons N should be at least of size 30. The number of months within a year (K) is variable and, of course, is restricted to integer values such that $1 \leq K \leq 12$.

Output

To facilitate description of the computational aspects of TEMPROB, order statistics are introduced. Let $x'_i$ represent the $i^{th}$ order statistic of the annual extreme minimum temperature data where $i = 1, \ldots, N$. Also,

$$x'_1 < x'_2 < \ldots < x'_N.$$

The multipartite output consists of five items:

1) Original chronologically ordered data input list and sort on monthly data for annual extreme minimum temperature. For an example, see page 28.

2) Arrangement of annual extreme minimum temperatures in descending order. This generates $x'_N$ to $x'_1$. An index M from 1 to N and the ratio M/(N + 1) is printed along with the order statistics. For example, see page 29. (The ratio M/(N + 1) is computed and printed solely as a convenience for graphing the original data on Weather Bureau Form 811-2 or similar graph paper.)

3) Arrangement of chronologically ordered annual data in 1) above into a matrix of order (N/10) x 10, each row constituting a subgroup of size 10. The column sums of this matrix are formed, Lieblein's weights for subgroup size 10 are printed, the $\alpha$ and $\beta$ parameter estimates of the cdf are computed, and the mean and variance of the cdf are computed. For example, see page 30.

4) The reduced variate z where $z = (x - \alpha)/\beta$ where $\beta < 0$ is computed first for $x = x'_N$ , then z is computed in unit decrements for x to $x = x'_1$. In addition, the two probabilities $F(x_\circ)$ and $P = 1 - F(x_\circ)$ are computed for each value of the reduced variate. $F(x_\circ)$ is the probability that temperature $x_\circ$ or below will not occur; alternatively, it may be interpreted as the probability

that $x_o$ will be exceeded. $P = 1 - F(x_o)$ is the probability that a temperature equal to or less than $x_o$ will occur.

$F(x_o)$ is computed from:

$$(19) \qquad F(x) = \exp[-e^{-z}].$$

Equation (19) can be considered a complement cdf to the $P = 1 - F(x_o)$ cdf. Recall that if $f(x)$ is the pdf of x then:

$$(20) \qquad \int_{-\infty}^{\infty} f(x)dx = \int_{-\infty}^{x} f(x)dx + \int_{x}^{\infty} f(x)dx$$

where $-\infty \leq x \leq \infty$ , and that

$$(21) \qquad \int_{-\infty}^{\infty} f(x)dx = 1$$

In TEMPROB,

$$(22) \qquad \int_{-\infty}^{x} f(x)dx$$

is the cdf of x and is denoted in the output by P. Also,

$$(23) \qquad \int_{x}^{\infty} f(x)dx$$

is the complement cdf to (22), and is denoted in TEMPROB output by F(x).

The associated return period $T(x_o) = 1/P(x_o)$ is computed at this point in the program. For example, see page 31.

5) The statistic W(v) may be computed for each x as in 4) above for up to 3 different values of v. The restriction on v is that it must be an integer value such that $1 \leq v \leq 99$. The value of W(v) is an estimate of the probability that a particular temperature x will occur at least once within v years.[6] Computation of the W(v) statistic may be suppressed. For example, see pages 23-25.

All operations in the program are performed in double-precision. However, small rounding errors may be encountered in the T(x) or W(v) statistic (second or third decimal place) due to decimal bases in the program being transferred to hexdecimal bases in the arithmetic unit of the computer and subsequently transferred back to decimal bases.

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[6] Caution must be exercised in comparing the W(v) statistic with the T(x) statistic. The Fisher-Tippett Type I extreme minimum value distribution is asymmetric (skewed to the left) and thus exhibits some peculiarities. For example, if the return period T(x) for event x is 100 years this means that, <u>on the average</u>, event x happens once each 100 years. However, W(100) = .63. Thus, the event x has a 63% chance of occurring at least once within 100 years even though, on the average, it occurs once every 100 years. See [8, p. 3].

## TEMPROB CONVENTIONS

The following pages are coding sheets defining the formats and control card conventions of the TEMPROB program. In addition, two example problems with input and output are illustrated. In defining the TEMPROB conventions that follow it was assumed the user possesses some knowledge of FORTRAN IV.

### Program Control and Data Cards

Five groups of cards, in the following order, are necessary: 1) the Main Problem Control Card, 2) the data cards, 3) the Lieblein Weights Cards, 4) the Variable Format Output Title Control Cards, and 5) the W(v) Statistic Control Cards.

### Main Problem Control Card

1. Number of years of data, $10 \leq N \leq 70$ where N/10 is an integer value (Format: I2)
   9 10
2. Number of months within a year $1 \leq K \leq 12$ (Format: I2)
   13 14
3. W(v) statistic deletion control (Format: I1)
   "0" - - delete W(v)
   "1" - - compute W(v)
   18
4. First observation year minus one (e.g. if first observation year is 1930 punch 1929) (Format: I4)
   19 20 21 22

### Data Cards

Each card of the data deck inputs monthly extreme minimum temperatures for one year. Thus, each card of the data deck will contain K punched fields with format 6X, 12I4 (right adjusted). The first 6 columns may be used for appropriate identification of the annual observations. Of course, there will be N cards in the data deck.

The data input format may be changed to read any grouping of months from the data cards. The only restriction is that the number of months (K) must conform to $1 \leq K \leq 12$. For example, if monthly data from January through December were punched one year per card and the user wished to read only the March and April data, the data input format would be 14X, 2I4.

The data input format card carries label "51" and is the 14th card in the source statement deck. The user should note that the format declaration must remain the I field even though the value of K is variable.

The Lieblein Weights Cards

Two cards are required to input Lieblein weights for subgroup size 10. The first of these cards inputs the following $a_{.j}$ constants, with format 10F8.6

| cc | $a_{.j}$ |
|---|---|
| 1 - 8 | 0.230001 |
| 9 - 16 | 0.164178 |
| 17 - 24 | 0.134239 |
| 25 - 32 | 0.112414 |
| 33 - 40 | 0.094638 |
| 41 - 48 | 0.079263 |
| 49 - 56 | 0.065408 |
| 57 - 64 | 0.052496 |
| 65 - 72 | 0.040034 |
| 73 - 80 | 0.027331 |

The second card, with format 10F8.6, inputs the following $b_{\cdot j}$ constants. Note that $b_{1j}$, $b_{2j}$, and $b_{3j}$ are negative.

| cc | $b_{\cdot j}$ |
|---|---|
| 1 - 8 | -.324597 |
| 9 - 16 | -.085070 |
| 17 - 24 | -.017927 |
| 25 - 32 | .020698 |
| 33 - 40 | .045420 |
| 41 - 48 | .061652 |
| 49 - 56 | .071876 |
| 57 - 64 | .077242 |
| 65 - 72 | .077971 |
| 73 - 80 | .072734 |

Variable Format Output Title Control Cards

This group comprises 4 cards, the first 3 of which input appropriate problem identification and titles for the output of 1) above. The last card of the four inputs the variable format for the output of 1) above. Not all the column space provided by the first 3 cards of this group may be needed for output identification; however 3 cards must appear even though the third card may be blank. (The use of these Variable Format Cards is illustrated by examples below.)

W(v) Statistic Control Cards

This group is a sequence of up to 4 cards which control the computations associated with W(v). If column 18 of the Main

Problem Control Card is punched "0" then no W(v) statistic is computed; hence no W(v) Statistic Control Cards are needed. If column 18 of the Main Problem Card is punched "1" then 2 to 4 cards are needed in the following order:

1. Number of different v values to be specified. Since the program allows a maximum of 3 different v values per job the number specified is either 1, 2, or 3. (Format: I1) $\overline{10}$

2. The <u>value</u> of v is specified, one value per card, on the appropriate number of cards. The restriction on v is $1 \leq v \leq 99$. (Format: I2). $\overline{9}$ $\overline{10}$

## EXAMPLES

Two examples of problems amenable to TEMPROB follow. They were chosen to demonstrate the flexibility of TEMPROB input with respect to number of months.

Problem A.

Compute temperature probabilities and the value of W(v) for v = 1, v = 5, and v = 7 using January extreme minimum temperature data for Brownsville, Texas from 1930 to 1959 inclusive [see 8, pp. 6-8].

Note that N = 30, hence N/10 = 3, an integer value. Also, K = 1. The Main Problem Control Card contains the following punches:

| cc | Punch | Information |
|---|---|---|
| 9 - 10 | 30 | N = 30 |
| 14 | 1 | K = 1 (one month) |
| 18 | 1 | Compute W(v) |
| 19 - 22 | 1929 | Year preceeding first year of data |

The 30 data cards input the January extreme minimum temperature for each year from 1930 to 1959. For example, the first card is punched:

| cc | Punch | Information |
|---|---|---|
| 1 - 4 | 1930 | Identify card as 1930 observation |
| 9 - 10 | 24 | Minimum temperature for January, 1930 |

The Lieblein Weights Cards appear precisely as previously defined.

The Variable Format Output Title Control Cards appear as:

First Card: (cc. 1-80)

```
('1',3(1),45X,'EXTREME MINIMUM TEMPERATURES BY MONTHS'/' ',52X,'BROWNSVILLE, TEX
```

Second Card: (cc. 1-70)

```
AS'/'0',30X,'YEAR',20X,'JAN',25X,'ANNUAL'/' ',79X,'MINIMUM TEMP.'/'0')
```

Third Card: (cc. 1-26)

```
(' ',30X,I4,20X,I2,28X,I2)
```

The W(v) Statistic Control Cards are a set of 4 cards punched as follows:

| Card No. | cc | Punch | Information |
|---|---|---|---|
| 1 | 10 | 3 | 3 different v values to follow |
| 2 | 10 | 1 | v = 1 |
| 3 | 10 | 5 | v = 5 |
| 4 | 10 | 7 | v = 7 |

The output from this job follows.

To aid the reader in interpreting output from TEMPROB, interpretation of specific examples from the last 4 pages of output from Problem A follow. Suppose a firm engaged in production and/or marketing a vegetable crop in Brownsville, Texas is interested in the probability of crop loss from a freeze during January. Suppose the manager of the operation decides that 30°F. is the relevant temperature threshold to consider given the unique aspects of the operation (e.g. variety, proximity of acreage to ground cover, etc.). That is, 30°F. represents the threshold temperature which, in his judgement, may extensively damage the crop.

From Problem A, page 22, the probability that a temperature of 30°F. or below will not occur is .797 (F(x) in output). Of course, the probability that a temperature of 30°F. or below will occur is .203 (denoted P in output).

The return period for 30°F. is 4.9 years (T(x) in output). This means that about 4.9 years will elapse, on the average, before a temperature equal to or below 30°F. will occur. Thus, the manager might anticipate some crop loss due to low temperatures about once every 5 years.

The W(v) statistic for v = 1, v = 3, and v = 7 is given in the last 3 pages of output. Note that when v = 1 then W(v) = P in the output. The W(v) statistic for v = 3 is .494. This means that there is about a 50% chance of 30°F. or below occurring at least once within 3 years. Similarly, when v = 7, W(v) = .796 which means that there is about an 80% chance of 30°F. or below occurring at least once within 7 years.

OUTPUT- PROBLEM A

EXTREME MINIMUM TEMPERATURES BY MONTHS
BROWNSVILLE, TEXAS

| YEAR | JAN | ANNUAL MINIMUM TEMP. |
|---|---|---|
| 1930 | 24 | 24 |
| 1931 | 41 | 41 |
| 1932 | 40 | 40 |
| 1933 | 38 | 38 |
| 1934 | 42 | 42 |
| 1935 | 25 | 25 |
| 1936 | 32 | 32 |
| 1937 | 37 | 37 |
| 1938 | 34 | 34 |
| 1939 | 46 | 46 |
| 1940 | 25 | 25 |
| 1941 | 35 | 35 |
| 1942 | 33 | 33 |
| 1943 | 27 | 27 |
| 1944 | 32 | 32 |
| 1945 | 39 | 39 |
| 1946 | 36 | 36 |
| 1947 | 30 | 30 |
| 1948 | 28 | 28 |
| 1949 | 23 | 23 |
| 1950 | 39 | 39 |
| 1951 | 25 | 25 |
| 1952 | 42 | 42 |
| 1953 | 38 | 38 |
| 1954 | 35 | 35 |
| 1955 | 36 | 36 |
| 1956 | 37 | 37 |
| 1957 | 33 | 33 |
| 1958 | 38 | 38 |
| 1959 | 31 | 31 |

| INDEX | TEMP. IN ORDER | M/(N+1) |
|---|---|---|
| 1 | 46 | 0.032 |
| 2 | 42 | 0.065 |
| 3 | 42 | 0.097 |
| 4 | 41 | 0.129 |
| 5 | 40 | 0.161 |
| 6 | 39 | 0.194 |
| 7 | 39 | 0.226 |
| 8 | 38 | 0.258 |
| 9 | 38 | 0.290 |
| 10 | 38 | 0.323 |
| 11 | 37 | 0.355 |
| 12 | 37 | 0.387 |
| 13 | 36 | 0.419 |
| 14 | 36 | 0.452 |
| 15 | 35 | 0.484 |
| 16 | 35 | 0.516 |
| 17 | 34 | 0.548 |
| 18 | 33 | 0.581 |
| 19 | 33 | 0.613 |
| 20 | 32 | 0.645 |
| 21 | 32 | 0.677 |
| 22 | 31 | 0.710 |
| 23 | 30 | 0.742 |
| 24 | 28 | 0.774 |
| 25 | 27 | 0.806 |
| 26 | 25 | 0.839 |
| 27 | 25 | 0.871 |
| 28 | 25 | 0.903 |
| 29 | 24 | 0.935 |
| 30 | 23 | 0.968 |

ARRANGING DATA WITHIN SUBGROUPS IN ORDER OF DECREASING MAGNITUDE

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 46 | 42 | 41 | 40 | 38 | 37 | 34 | 32 | 25 | 24 |
| | 39 | 36 | 35 | 33 | 32 | 30 | 28 | 27 | 25 | 23 |
| | 42 | 39 | 38 | 38 | 37 | 36 | 35 | 33 | 31 | 25 |
| S.J= | 127 | 117 | 114 | 111 | 107 | 103 | 97 | 92 | 81 | 72 |

A.J= 0.230001 0.164178 0.134239 0.112414 0.094638 0.079263 0.065408 0.052496 0.040034
0.027331

A.J S.J= 29.210110 19.208810 15.303240 12.477950 10.126260
8.164085 6.344575 4.829632 3.242754 1.967832

SUM A.J S.J= 110.875200 ALPH= 36.958400

B.J= -0.324597 -0.085070 -0.017927 0.020698 0.045420 0.061652 0.071876 0.077242 0.077971
0.072734

B.J S.J=-41.225810 -9.953191 -2.043677 2.297478 4.859940
6.350156 6.971971 7.106265 6.315649 5.236848

SUM B.J S.J= -14.06232 BETA= -4.69411

MEAN=ALPH-0.577*BETA= 39.66690 VARIANCE=1.645*BETA**2= 36.24696

| INDEX | TEMP. FROM MAX. TO MIN. | Z=(X-ALPH)/BETA | F=EXP(-E**(-Z)) | P=1-F(X) | T(X)=1/P |
|---|---|---|---|---|---|
| 1 | 46 | -1.926 | 0.001 | 0.999 | 1.001 |
| 2 | 45 | -1.713 | 0.004 | 0.996 | 1.004 |
| 3 | 44 | -1.500 | 0.011 | 0.989 | 1.011 |
| 4 | 43 | -1.287 | 0.027 | 0.973 | 1.027 |
| 5 | 42 | -1.074 | 0.054 | 0.946 | 1.057 |
| 6 | 41 | -0.861 | 0.094 | 0.906 | 1.104 |
| 7 | 40 | -0.648 | 0.148 | 0.852 | 1.173 |
| 8 | 39 | -0.435 | 0.213 | 0.787 | 1.271 |
| 9 | 38 | -0.222 | 0.287 | 0.713 | 1.402 |
| 10 | 37 | -0.009 | 0.365 | 0.635 | 1.574 |
| 11 | 36 | 0.204 | 0.442 | 0.558 | 1.794 |
| 12 | 35 | 0.417 | 0.517 | 0.483 | 2.072 |
| 13 | 34 | 0.630 | 0.587 | 0.413 | 2.422 |
| 14 | 33 | 0.843 | 0.650 | 0.350 | 2.860 |
| 15 | 32 | 1.056 | 0.706 | 0.294 | 3.405 |
| 16 | 31 | 1.269 | 0.755 | 0.245 | 4.082 |
| 17 | 30 | 1.482 | 0.797 | 0.203 | 4.922 |
| 18 | 29 | 1.695 | 0.832 | 0.168 | 5.964 |
| 19 | 28 | 1.908 | 0.862 | 0.138 | 7.255 |
| 20 | 27 | 2.121 | 0.887 | 0.113 | 8.853 |
| 21 | 26 | 2.335 | 0.908 | 0.092 | 10.832 |
| 22 | 25 | 2.548 | 0.925 | 0.075 | 13.282 |
| 23 | 24 | 2.761 | 0.939 | 0.061 | 16.314 |
| 24 | 23 | 2.974 | 0.950 | 0.050 | 20.066 |

| V | TEMP. FROM MAX. TO MIN. | W(V) |
|---|---|---|
| 1 | 46 | 0.999 |
| 1 | 45 | 0.996 |
| 1 | 44 | 0.989 |
| 1 | 43 | 0.973 |
| 1 | 42 | 0.946 |
| 1 | 41 | 0.906 |
| 1 | 40 | 0.852 |
| 1 | 39 | 0.787 |
| 1 | 38 | 0.713 |
| 1 | 37 | 0.635 |
| 1 | 36 | 0.558 |
| 1 | 35 | 0.483 |
| 1 | 34 | 0.413 |
| 1 | 33 | 0.350 |
| 1 | 32 | 0.294 |
| 1 | 31 | 0.245 |
| 1 | 30 | 0.203 |
| 1 | 29 | 0.168 |
| 1 | 28 | 0.138 |
| 1 | 27 | 0.113 |
| 1 | 26 | 0.092 |
| 1 | 25 | 0.075 |
| 1 | 24 | 0.061 |
| 1 | 23 | 0.050 |

| V | TEMP. FROM MAX. TO MIN. | W(V) |
|---|---|---|
| 3 | 46 | 1.000 |
| 3 | 45 | 1.000 |
| 3 | 44 | 1.000 |
| 3 | 43 | 1.000 |
| 3 | 42 | 1.000 |
| 3 | 41 | 0.999 |
| 3 | 40 | 0.997 |
| 3 | 39 | 0.990 |
| 3 | 38 | 0.976 |
| 3 | 37 | 0.952 |
| 3 | 36 | 0.913 |
| 3 | 35 | 0.861 |
| 3 | 34 | 0.798 |
| 3 | 33 | 0.725 |
| 3 | 32 | 0.648 |
| 3 | 31 | 0.570 |
| 3 | 30 | 0.494 |
| 3 | 29 | 0.423 |
| 3 | 28 | 0.359 |
| 3 | 27 | 0.302 |
| 3 | 26 | 0.252 |
| 3 | 25 | 0.209 |
| 3 | 24 | 0.173 |
| 3 | 23 | 0.142 |

| V | TEMP. FROM MAX. TO MIN. | W(V) |
|---|---|---|
| 7 | 46 | 1.000 |
| 7 | 45 | 1.000 |
| 7 | 44 | 1.000 |
| 7 | 43 | 1.000 |
| 7 | 42 | 1.000 |
| 7 | 41 | 1.000 |
| 7 | 40 | 1.000 |
| 7 | 39 | 1.000 |
| 7 | 38 | 1.000 |
| 7 | 37 | 0.999 |
| 7 | 36 | 0.997 |
| 7 | 35 | 0.990 |
| 7 | 34 | 0.976 |
| 7 | 33 | 0.951 |
| 7 | 32 | 0.912 |
| 7 | 31 | 0.860 |
| 7 | 30 | 0.796 |
| 7 | 29 | 0.723 |
| 7 | 28 | 0.646 |
| 7 | 27 | 0.568 |
| 7 | 26 | 0.492 |
| 7 | 25 | 0.422 |
| 7 | 24 | 0.358 |
| 7 | 23 | 0.301 |

*Problem B*

Compute temperature probabilities and the value of W(v) for v = 10 using monthly data November through March 1920-21 to November through March 1969-70 for Weslaco, Texas.

Note that N = 50, hence N/10 = 5, an integer value. Also, K = 5. The Main Problem Control Card contains the following punches:

| cc | Punch | Information |
|---|---|---|
| 9 - 10 | 54 | N = 50 |
| 14 | 5 | K = 5 |
| 18 | 1 | Compute W(v) |
| 19 - 22 | 1919 | Year preceeding first year of data. |

The 50 data cards input November through March extreme minimum temperature for each year 1920-21 through 1969-70. The punches are as specified above for "Data Cards."

Again the Lieblein Weights Cards appear precisely as previously defined.

The Variable Format Title Control Cards appear as:

First Card: (cc. 1-80)

```
('1',3( ),45X,'EXTREME MINIMUM TEMPERATURES BY MONTHS'/' ',57X,'WESLACO, TEXAS'/
```

Second Card: (cc. 1-80)

```
'0',30X,'YEAR',7X,'NOV',7X,'DEC',7x,'JAN',7X'FEB',7X'MAR',15X,'ANNUAL'/',93X,'
```

Third Card: (cc. 1-19)

```
MINIMUM TEMP.'/'0')
```

Fourth Card: (cc. 1-49)

('  ',30X,I4,8X,I2,8X, I2,8X,I2,8X,I2,8X,I2,14X,I2)

The W(v) Statistic Control Cards are a set of 2 cards punched as follows:

| Card No. | cc | Punch | Information |
|---|---|---|---|
| 1 | 10 | 1 | 1 v value to follow |
| 2 | 9 - 10 | 10 | v = 10 |

The output from this job follows.

OUTPUT- PROBLEM B

EXTREME MINIMUM TEMPERATURES BY MONTHS
WESLACO, TEXAS

| YEAR | NOV | DEC | JAN | FEB | MAR | ANNUAL MINIMUM TEMP. |
|---|---|---|---|---|---|---|
| 1920 | 31 | 30 | 36 | 34 | 50 | 30 |
| 1921 | 46 | 35 | 33 | 33 | 27 | 27 |
| 1922 | 41 | 37 | 39 | 27 | 38 | 27 |
| 1923 | 46 | 40 | 33 | 32 | 39 | 32 |
| 1924 | 42 | 26 | 27 | 42 | 46 | 26 |
| 1925 | 37 | 23 | 30 | 38 | 46 | 23 |
| 1926 | 35 | 32 | 32 | 36 | 37 | 32 |
| 1927 | 42 | 31 | 26 | 35 | 38 | 26 |
| 1928 | 42 | 33 | 33 | 30 | 36 | 30 |
| 1929 | 38 | 27 | 21 | 42 | 38 | 21 |
| 1930 | 38 | 33 | 35 | 46 | 33 | 33 |
| 1931 | 51 | 38 | 36 | 43 | 31 | 31 |
| 1932 | 35 | 28 | 29 | 27 | 42 | 27 |
| 1933 | 42 | 34 | 41 | 36 | 32 | 32 |
| 1934 | 41 | 34 | 24 | 27 | 40 | 24 |
| 1935 | 41 | 37 | 27 | 29 | 47 | 27 |
| 1936 | 38 | 34 | 38 | 38 | 34 | 34 |
| 1937 | 35 | 34 | 30 | 33 | 52 | 30 |
| 1938 | 30 | 34 | 41 | 35 | 41 | 30 |
| 1939 | 39 | 31 | 23 | 32 | 37 | 23 |
| 1940 | 30 | 39 | 27 | 37 | 37 | 27 |
| 1941 | 44 | 41 | 32 | 35 | 34 | 32 |
| 1942 | 39 | 29 | 26 | 34 | 35 | 26 |
| 1943 | 34 | 31 | 27 | 41 | 38 | 27 |
| 1944 | 37 | 28 | 36 | 38 | 44 | 28 |
| 1945 | 46 | 32 | 32 | 37 | 41 | 32 |
| 1946 | 41 | 34 | 30 | 32 | 38 | 30 |
| 1947 | 41 | 34 | 28 | 31 | 32 | 28 |
| 1948 | 32 | 35 | 20 | 40 | 48 | 20 |
| 1949 | 39 | 33 | 39 | 37 | 41 | 33 |
| 1950 | 32 | 24 | 26 | 19 | 31 | 19 |
| 1951 | 32 | 33 | 38 | 33 | 35 | 32 |
| 1952 | 42 | 35 | 36 | 43 | 43 | 35 |
| 1953 | 37 | 28 | 33 | 36 | 37 | 28 |
| 1954 | 39 | 37 | 31 | 28 | 38 | 28 |
| 1955 | 38 | 33 | 35 | 33 | 37 | 33 |
| 1956 | 32 | 38 | 34 | 47 | 41 | 32 |
| 1957 | 35 | 26 | 32 | 31 | 39 | 26 |
| 1958 | 39 | 28 | 31 | 39 | 46 | 28 |
| 1959 | 32 | 32 | 32 | 29 | 37 | 29 |
| 1960 | 40 | 35 | 32 | 33 | 45 | 32 |
| 1961 | 46 | 35 | 16 | 40 | 38 | 16 |
| 1962 | 43 | 38 | 23 | 30 | 39 | 23 |
| 1963 | 36 | 29 | 29 | 33 | 42 | 29 |
| 1964 | 42 | 30 | 33 | 31 | 33 | 30 |
| 1965 | 47 | 40 | 28 | 33 | 34 | 28 |
| 1966 | 34 | 29 | 29 | 31 | 43 | 29 |
| 1967 | 43 | 33 | 31 | 31 | 36 | 31 |
| 1968 | 38 | 34 | 29 | 42 | 39 | 29 |
| 1969 | 32 | 38 | 28 | 38 | 39 | 28 |

| INDEX | TEMP. IN ORDER | M/(N+1) |
|---|---|---|
| 1 | 35 | 0.020 |
| 2 | 34 | 0.039 |
| 3 | 33 | 0.059 |
| 4 | 33 | 0.078 |
| 5 | 33 | 0.098 |
| 6 | 32 | 0.118 |
| 7 | 32 | 0.137 |
| 8 | 32 | 0.157 |
| 9 | 32 | 0.176 |
| 10 | 32 | 0.196 |
| 11 | 32 | 0.216 |
| 12 | 32 | 0.235 |
| 13 | 32 | 0.255 |
| 14 | 31 | 0.275 |
| 15 | 31 | 0.294 |
| 16 | 30 | 0.314 |
| 17 | 30 | 0.333 |
| 18 | 30 | 0.353 |
| 19 | 30 | 0.373 |
| 20 | 30 | 0.392 |
| 21 | 30 | 0.412 |
| 22 | 29 | 0.431 |
| 23 | 29 | 0.451 |
| 24 | 29 | 0.471 |
| 25 | 29 | 0.490 |
| 26 | 28 | 0.510 |
| 27 | 28 | 0.529 |
| 28 | 28 | 0.549 |
| 29 | 28 | 0.569 |
| 30 | 28 | 0.588 |
| 31 | 28 | 0.608 |
| 32 | 28 | 0.627 |
| 33 | 27 | 0.647 |
| 34 | 27 | 0.667 |
| 35 | 27 | 0.686 |
| 36 | 27 | 0.706 |
| 37 | 27 | 0.725 |
| 38 | 27 | 0.745 |
| 39 | 26 | 0.765 |
| 40 | 26 | 0.784 |
| 41 | 26 | 0.804 |
| 42 | 26 | 0.824 |
| 43 | 24 | 0.843 |
| 44 | 23 | 0.863 |
| 45 | 23 | 0.882 |
| 46 | 23 | 0.902 |
| 47 | 21 | 0.922 |
| 48 | 20 | 0.941 |
| 49 | 19 | 0.961 |
| 50 | 16 | 0.980 |

ARRANGING DATA WITHIN SUBGROUPS IN ORDER OF DECREASING MAGNITUDE

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 32 | 32 | 30 | 30 | 27 | 27 | 26 | 26 | 23 | 21 |
| | 34 | 33 | 32 | 31 | 30 | 30 | 27 | 27 | 24 | 23 |
| | 33 | 32 | 32 | 30 | 28 | 28 | 27 | 27 | 26 | 20 |
| | 35 | 33 | 32 | 32 | 29 | 28 | 28 | 28 | 26 | 19 |
| | 32 | 31 | 30 | 29 | 29 | 29 | 28 | 28 | 23 | 16 |
| S.J= | 166 | 161 | 156 | 152 | 143 | 142 | 136 | 136 | 122 | 99 |

```
A.J=  0.230001  0.164178  0.134239  0.112414  0.094638  0.079263  0.065408  0.052496  0.040034
      0.027331

A.J S.J= 38.180160     26.432640     20.941280     17.086910     13.533230
         11.255340      8.895487      7.139456      4.884148      2.705769

         SUM A.J S.J=  151.054300                  ALPH=   30.210870

B.J= -0.324597 -0.085070 -0.017927  0.020698  0.045420  0.061652  0.071876  0.077242  0.077971
      0.072734

B.J S.J=-53.883080    -13.696270     -2.796611      3.146095      6.495059
          8.754583      9.775134     10.504910      9.512460      7.200665

         SUM B.J S.J=  -14.98697                   BETA=   -2.99739

    MEAN=ALPH-0.577*BETA=   31.94037        VARIANCE=1.645*BETA**2=   14.77929
```

| INDEX | TEMP. FROM MAX. TO MIN. | Z=(X-ALPH)/BETA | F=EXP(-E**(-Z)) | P=1-F(X) | T(X)=1/P |
|---|---|---|---|---|---|
| 1 | 35 | -1.598 | 0.007 | 0.993 | 1.007 |
| 2 | 34 | -1.264 | 0.029 | 0.971 | 1.030 |
| 3 | 33 | -0.931 | 0.079 | 0.921 | 1.086 |
| 4 | 32 | -0.597 | 0.163 | 0.837 | 1.194 |
| 5 | 31 | -0.263 | 0.272 | 0.728 | 1.374 |
| 6 | 30 | 0.070 | 0.394 | 0.606 | 1.649 |
| 7 | 29 | 0.404 | 0.513 | 0.487 | 2.053 |
| 8 | 28 | 0.738 | 0.620 | 0.380 | 2.631 |
| 9 | 27 | 1.071 | 0.710 | 0.290 | 3.447 |
| 10 | 26 | 1.405 | 0.782 | 0.218 | 4.595 |
| 11 | 25 | 1.738 | 0.839 | 0.161 | 6.203 |
| 12 | 24 | 2.072 | 0.882 | 0.118 | 8.452 |
| 13 | 23 | 2.406 | 0.914 | 0.086 | 11.594 |
| 14 | 22 | 2.739 | 0.937 | 0.063 | 15.982 |
| 15 | 21 | 3.073 | 0.955 | 0.045 | 22.110 |
| 16 | 20 | 3.407 | 0.967 | 0.033 | 30.665 |
| 17 | 19 | 3.740 | 0.977 | 0.023 | 42.609 |
| 18 | 18 | 4.074 | 0.983 | 0.017 | 59.283 |
| 19 | 17 | 4.407 | 0.988 | 0.012 | 82.561 |
| 20 | 16 | 4.741 | 0.991 | 0.009 | 115.057 |

| V | TEMP. FROM MAX. TO MIN. | W(V) |
|---|---|---|
| 10 | 35 | 1.000 |
| 10 | 34 | 1.000 |
| 10 | 33 | 1.000 |
| 10 | 32 | 1.000 |
| 10 | 31 | 1.000 |
| 10 | 30 | 1.000 |
| 10 | 29 | 0.999 |
| 10 | 28 | 0.992 |
| 10 | 27 | 0.967 |
| 10 | 26 | 0.914 |
| 10 | 25 | 0.828 |
| 10 | 24 | 0.716 |
| 10 | 23 | 0.594 |
| 10 | 22 | 0.476 |
| 10 | 21 | 0.371 |
| 10 | 20 | 0.282 |
| 10 | 19 | 0.211 |
| 10 | 18 | 0.156 |
| 10 | 17 | 0.115 |
| 10 | 16 | 0.084 |

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# APPENDIX

The following pages contain a listing of the source statements of TEMPROB.

```
$JOB X025M2,TIME=001,PAGES=010  THOMAS L. SPORLEDER
      INTEGER TEMP(100,12),MIN(100),YEAR,SAVE(100),STORE1(10),STORE2(10)
     *,STORE3(10),STORE4(10),STORE5(10),STORE6(10),SUM(10),K(100),V(10),
     *IJK(100),FMT1(60),FMT2(20),TWN,STORE7(10),STORE8(10)
      REAL DIV(100),AJ(10),BJ(10),AJSJ(10),BJSJ(10),MEAN,Z(100),X(100),
     *F(100),P(100),W(100),TOT(100),T(100)
C  READ IN THE NUMBER OF YEARS AND THE NUMBER OF MONTHS AND TEST VALUE
C  OF CALCULATING W(V).
      READ(5,50) NY,NM,TWV,IYEAR
   50 FORMAT(6X,12I4)
C  READ IN TEMPERATURES
C  STEP-1 SELECT THE SMALLEST TEMPERATURE BY YEAR & PRINT OUT
      DO 90 I1=1,NY
      READ(5,51) (TEMP(I1,J1),J1=1,NM)
   51 FORMAT(14X,5I4)
      IF(NM.GT.1) GO TO 90
      MIN(I1)=TEMP(I1,1)
      SAVE(I1)=MIN(I1)
   90 CONTINUE
      READ(5,52) (AJ(I),I=1,10)
      READ(5,52) (BJ(J),J=1,10)
   52 FORMAT(10F8.6)
      READ(5,54) (FMT1(I),I=1,60)
   54 FORMAT(20A4)
      READ(5,54) (FMT2(J),J=1,20)
      READ(5,50) KING
      DO 206 MJ1=1,KING
  206 READ(5,50) V(MJ1)
      IF(NM.EQ.1) GO TO 300
      DO 91 K1=1,NY
      LITT=TEMP(K1,1)
      DO 92 L1=2,NM
      IF(TEMP(K1,L1).LE.LITT) LITT=TEMP(K1,L1)
   92 CONTINUE
      SAVE(K1)=LITT
      MIN(K1)=LITT
   91 CONTINUE
  300 WRITE(6,FMT1)
      DO 93 M1=1,NY
      YEAR=IYEAR+M1
   93 WRITE(6,FMT2) YEAR,(TEMP(M1,N1),N1=1,NM),MIN(M1)
C  STEP-2 SORT THE EXTREME MINIMUM TEMP. IN DESCENDING ORDER
      NYM1=NY-1
      DO 98 I2=1,NYM1
      I2P1=I2+1
      DO 98 J2=I2P1,NY
      IF(MIN(I2).GE.MIN(J2)) GO TO 98
      IMD=MIN(I2)
      MIN(I2)=MIN(J2)
      MIN(J2)=IMD
   98 CONTINUE
      WRITE(6,62)
   62 FORMAT('1',3(/),43X,'INDEX',10X,'TEMP. IN ORDER',6X,'M/(N+1)'/'0')
C  STEP-3 PRINT OUT INDEX & TEMP. & M/(N+1)
```

```
      DO 94 K2=1,NY
      R2=K2
      RY=NY
      DIV(K2)=(R2/(RY+1,0))
   94 WRITE(6,63) K2,MIN(K2),DIV(K2)
   63 FORMAT(' ',42X,I2,18X,I2,12X,F6.3)
C  STEP-4 ARRANGE THE DATA BY SUBGROUP
      NSUB=NY/10
      DO 97 L2=1,NY
      IF(L2.LE.10) GO TO 1
      IF(L2.GE.11.AND.L2.LE.20)  GO TO 2
      IF(L2.GE.21.AND.L2.LE.30) GO TO 3
      IF(L2.GE.31.AND.L2.LE.40) GO TO 4
      IF(L2.GE.41.AND.L2.LE.50) GO TO 5
      IF(L2.GE.51.AND.L2.LE.60) GO TO 6
      IF(L2.GE.61.AND.L2.LE.70) GO TO 7
      IF(L2.GE.71.AND.L2.LE.80) GO TO 8
    1 STORE1(L2)=SAVE(L2)
      GO TO 97
    2 STORE2(L2-10)=SAVE(L2)
      GO TO 97
    3 STORE3(L2-20)=SAVE(L2)
      GO TO 97
    4 STORE4(L2-30)=SAVE(L2)
      GO TO 97
    5 STORE5(L2-40)=SAVE(L2)
      GO TO 97
    6 STORE6(L2-50)=SAVE(L2)
      GO TO 97
    7 STORE7(L2-60)=SAVE(L2)
      GO TO 97
    8 STORE8(L2-70)=SAVE(L2)
   97 CONTINUE
C  STEP-5 ARRANGE EACH SUBGROUP ROWWISE IN DESCENDING ORDER
      DO 101 I3=1,9
      I3P1=I3+1
      DO 101 J3=I3P1,10
      IF(STORE1(I3).GE.STORE1(J3)) GO TO 101
      JMD1=STORE1(I3)
      STORE1(I3)=STORE1(J3)
      STORE1(J3)=JMD1
  101 CONTINUE
      IF(NSUB.EQ.1) GO TO 400
      DO 102 K3=1,9
      K3P1=K3+1
      DO 102 L3=K3P1,10
      IF(STORE2(K3).GE.STORE2(L3)) GO TO 102
      JMD2=STORE2(K3)
      STORE2(K3)=STORE2(L3)
      STORE2(L3)=JMD2
  102 CONTINUE
      IF(NSUB.EQ.2) GO TO 400
      DO 103 M3=1,9
      M3P1=M3+1
      DO 103 N3=M3P1,10
      IF(STORE3(M3).GE.STORE3(N3)) GO TO 103
      JMD3=STORE3(M3)
      STORE3(M3)=STORE3(N3)
      STORE3(N3)=JMD3
```

```
      IF(NSUB.EQ.3) GO TO 400
      DO 104 I4=1,9
      I4P1=I4+1
      DO 104 J4=I4P1,10
      IF(STORE4(I4).GE.STORE4(J4)) GO TO 104
      JMD4=STORE4(I4)
      STORE4(I4)=STORE4(J4)
      STORE4(J4)=JMD4
  104 CONTINUE
      IF(NSUB.EQ.4) GO TO 400
      DO 105 K4=1,9
      K4P1=K4+1
      DO 105 L4=K4P1,10
      IF(STORE5(K4).GE.STORE5(L4)) GO TO 105
      JMD5=STORE5(K4)
      STORE5(K4)=STORE5(L4)
      STORE5(L4)=JMD5
  105 CONTINUE
      IF(NSUB.EQ.5) GO TO 400
      DO 106 M4=1,9
      M4P1=M4+1
      DO 106 N4=M4P1,10
      IF(STORE6(M4).GE.STORE6(N4)) GO TO 106
      JMD6=STORE6(M4)
      STORE6(M4)=STORE6(N4)
      STORE6(N4)=JMD6
  106 CONTINUE
      IF(NSUB.EQ.6) GO TO 400
      DO 107 IA1=1,9
      IAP1=IA1+1
      DO 107 IB1=IAP1,10
      IF(STORE7(IA1).GE.STORE7(IB1)) GO TO 107
      IC1=STORE7(IA1)
      STORE7(IA1)=STORE7(IB1)
      STORE7(IB1)=IC1
  107 CONTINUE
      IF(NSUB.EQ.7) GO TO 400
      DO 108 JA1=1,9
      JAP1=JA1+1
      DO 108 JB1=JAP1,10
      IF(STORE8(JA1).GE.STORE8(JB1)) GO TO 108
      JC1=STORE8(JA1)
      STORE8(JA1)=STORE8(JB1)
      STORE8(JB1)=JC1
  108 CONTINUE
  400 WRITE(6,68)
   68 FORMAT('1',3(/),39X,'ARRANGING DATA WITHIN SUBGROUPS IN ORDER OF D
     *ECREASING MAGNITUDE'/'0')
      WRITE(6,66) (STORE1(I5),I5=1,10)
      IF(NSUB.EQ.1) GO TO 401
      WRITE(6,66) (STORE2(J5),J5=1,10)
      IF(NSUB.EQ.2) GO TO 401
      WRITE(6,66) (STORE3(K5),K5=1,10)
      IF(NSUB.EQ.3) GO TO 401
      WRITE(6,66) (STORE4(M5),M5=1,10)
      IF(NSUB.EQ.4) GO TO 401
      WRITE(6,66) (STORE5(N5),N5=1,10)
      IF(NSUB.EQ.5) GO TO 401
      WRITE(6,66) (STORE6(I6),I6=1,10)
      IF(NSUB.EQ.6) GO TO 401
```

```
      WRITE(6,66) (STORE7(KK1),KK1=1,10)
      IF(NSUB.EQ.7) GO TO 401
      WRITE(6,66) (STORE8(KK2),KK2=1,10)
   66 FORMAT('0',18X,10(I4,6X))
C  STEP-6 SUM EACH COLUM OF THE MATRICS
  401 CONTINUE
      DO 100 K6=1,10
      IF(NSUB.EQ.1) SUM(K6)=STORE1(K6)
      IF(NSUB.EQ.2) SUM(K6)=STORE1(K6)+STORE2(K6)
      IF(NSUB.EQ.3) SUM(K6)=STORE1(K6)+STORE2(K6)+STORE3(K6)
      IF(NSUB.EQ.4) SUM(K6)=STORE1(K6)+STORE2(K6)+STORE3(K6)+STORE4(K6)
      IF(NSUB.EQ.5) SUM(K6)=STORE1(K6)+STORE2(K6)+STORE3(K6)+STORE4(K6)
     *                     +STORE5(K6)
      IF(NSUB.EQ.6) SUM(K6)=STORE1(K6)+STORE2(K6)+STORE3(K6)+STORE4(K6)
     *                     +STORE5(K6)+STORE6(K6)
      IF(NSUB.EQ.7) SUM(K6)=STORE1(K6)+STORE2(K6)+STORE3(K6)+STORE4(K6)
     *                     +STORE5(K6)+STORE6(K6)+STORE7(K6)
      IF(NSUB.EQ.8) SUM(K6)=STORE1(K6)+STORE2(K6)+STORE3(K6)+STORE4(K6)
     *                     +STORE5(K6)+STORE6(K6)+STORE7(K6)+STORE8(K6)
  100 CONTINUE
      WRITE(6,67) (SUM(K7),K7=1,10)
   67 FORMAT('0',14X,'S.J=',10(I4,6X))
C  STEP-7 FORM SUM A.J S.J AND SUM B.J S.J, THEN PRINT THEM
C  STEP-8 FORM ALPH,BETA,MEAN, AND VARIANCE, THEN PRINT THEM
      DO 201 IJ1=1,10
      TOT(IJ1)=SUM(IJ1)
  201 AJSJ(IJ1)=AJ(IJ1)*TOT(IJ1)
      TOTAL1=0.
      DO 202 IJ2=1,10
  202 TOTAL1=TOTAL1+AJSJ(IJ2)
      AA=TOTAL1/NSUB
      DO 203 IJ3=1,10
  203 BJSJ(IJ3)=BJ(IJ3)*TOT(IJ3)
      TOTAL2=0.
      DO 204 IJ4=1,10
  204 TOTAL2=TOTAL2+BJSJ(IJ4)
      BB=TOTAL2/NSUB
      WRITE(6,601) (AJ(IJ5),IJ5=1,10)
  601 FORMAT('0',14X,'A.J=',10F10.6)
      WRITE(6,602) (AJSJ(IJ6),IJ6=1,10)
  602 FORMAT('0', 3X,'A.J S.J=',10(F9.6,3X))
      WRITE(6,603) TOTAL1, AA
  603 FORMAT('0',26X,'SUM A.J S.J=',F12.6,15X,'ALPH=',F12.6)
      WRITE(6,604) (BJ(IJ7),IJ7=1,10)
  604 FORMAT('0',14X,'B.J=',10F10.6)
      WRITE(6,605) (BJSJ(IJ8),IJ8=1,10)
  605 FORMAT('0', 3X,'B.J S.J=',10(F10.6,2X))
      WRITE(6,606) TOTAL2,BB
  606 FORMAT('0',26X,'SUM B.J S.J=',F11.5,15X,'BETA=',F11.5)
      MEAN=AA-(0.577*BB)
      VARI=1.645*BB**2
      WRITE(6,607) MEAN, VARI
  607 FORMAT('0',18X,'MEAN=ALPH-0.577*BETA=',F11.5,10X,'VARIANCE=1.645*B
     *ETA**2=',F11.5)
C  STEP-9 CALCULATE Z,F(X),P, AND T(X), THEN PRINT THEM
      WRITE(6,608)
  608 FORMAT('1',3(/),20X,'INDEX', 5X,'TEMP. FROM MAX. TO MIN.',5X,
     *'Z=(X-ALPH)/BETA', 5X,'F=EXP(-E**(-Z))', 5X,'P=1-F(X)',7X,
     *'T(X)=1/P'/'0')
```

```
      MNP1=MNP+1
      DO 205 KJ1=1,MNP1
      IJK(KJ1)=MIN(1)-KJ1+1
      XIJ=IJK(KJ1)
      Z(KJ1)=(XIJ-AA)/BB
      A=(-2.71828**(-Z(KJ1)))
      F(KJ1)=EXP(A)
      P(KJ1)=1. - F(KJ1)
      T(KJ1)=1. / P(KJ1)
      WRITE(6,609) KJ1, IJK(KJ1), Z(KJ1), F(KJ1), P(KJ1), T(KJ1)
  609 FORMAT(' ',20X,I2,16X,I2,20X,F7.3,12X,F7.3,10X,F7.3,8X,F7.3)
  205 CONTINUE
      IF(TWV.EQ.0) GO TO 999
C  STEP-10 FORM W(V) AND PRINT IT
      DO 207 NJ1=1,KING
      WRITE(6,610)
  610 FORMAT('1',3(/),45X,'V',15X,'TEMP. FROM MAX. TO MIN.',13X,'W(V)')
      DO 208 NJ2=1,MNP1
      W(NJ2)=1. - ((1.-P(NJ2))**V(NJ1))
      WRITE(6,611) V(NJ1), IJK(NJ2), W(NJ2)
  611 FORMAT('0',43X,I2,27X,I2,19X,F7.3)
  208 CONTINUE
  207 CONTINUE
      WRITE(6,666)
  666 FORMAT('1')
  999 STOP
      END

$DATA
```