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Probit Analysis Program 1620-06.0.059

1620 PROBIT ANALYSIS PROGRAM

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Modifications or revisions to this program, as they occur, will be announced in the appropriate Catalog of Programs for IBM Data Processing Systems. When such an announcement occurs, users should order a complete new program from the Program Information Department.

PROBIT ANALYSIS

METHOD: The method described in D. J. Finney, Probit Analysis, Cambridge University Press, is used in this program. The FORTRAN notation follows as closely as possible that used in the text (e.g. FORTRAN "EN" is equivalent to Finney's "n", SMX2 is equivalent to Σnwx^2; such changes should be fairly obvious). An initial estimation of a = 5, b = 0 is used in the iteration.

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{t} e^{-\frac{x^2}{2}} \, dx$$

is approximated by a modification of a formula appearing in Hastings, Approximations for Digital Computers. The approximation is:

$$P = \frac{1}{\sqrt{2\pi}} e^{-\frac{t^2}{2}} \cdot \sqrt{2} \sum_{i=1}^{5} a_i u^i \quad \text{for } t<0$$

$$= 1 - \left[\frac{1}{\sqrt{2\pi}} e^{-t^2/2} \cdot \sqrt{2} \sum_{i=1}^{5} a_i u^i \right] \quad \text{for } t \geq 0$$

where $u = \left[1 + q \, |t|\right]^{-1}$

$a_1 = 0.22583685$, $a_2 = -0.25212867$

$a_3 = 1.2596951$, $a_4 = -1.2878224$

$a_5 = 0.94064607$, $9 = 0.23164189$

The probit slope, b, is iterated until the relative error (New b - old b/New b) $\leq$ .0001 or until 13 iterations are completed if the slope does not converge in fewer cycles. This accuracy may be altered by changing the constant in the statement EPSLN = 1. E-4 or the maximum number of cycles may be changed by altering the statement DO 4 J = 1, 13.

RESULTS: The program outputs include the probit equation (Probit = 2 $\pm$ b (log dose)), chi-square and the associated degrees of freedom, and the log of the expected dose, the expected dose, with 95% confidence limits on both, for a maximum of 10 levels (e.g. ED_{50}, ED_{98}); those levels chosen are a part of the input data.

RECOMPILATION: If it is desired to recompile the source program for use on a basic machine or to change any parameters the following restrictions must be observed.

a. Two extra subroutines are required. ABS refers to an absolute value subroutine. HEAD refers to a special purpose subroutine for printing the long alphabetic heading line. Symbolic listings of both subroutines follow the listing for the main program. They must be added to the FORTRAN subroutine deck according to the directions supplied in the FORTRAN write-up.

b. If the punched card output option is desired, FORTRAN must be modified to allow 80 columns of output. See 1620 Technical Bulletin # 115 (Technical Digest No.: 1620-PRG-20.44).

c. If the program is intended for a paper tape machine, output must be on the typewriter or the source program must be changed so that all "PUNCH" statements read "PUNCH TAPE". All "READ" statements must be changed to "READ TAPE" or "ACCEPT".

INPUT DATA:

1. One card containing A_1- A_5 in F-type notation. This card is constant and must be used with every run. It is included with the program deck.

2. One card containing M in cc 1-2. This is the number of P values for which ED computations are desired. M must be an integer ≤ 10.

3. M cards containing OP and OY (1 pair per card). "OP" is the "P" value on the printout and "OY" is its associated probit.

   cc 1-3 OP
   cc 4-11 OY

   Both values must be in Floating-point, F-type notation.

   The input cards already described remain constant for any one run. Following these are the data cards for each assay.

4. One card with title for assay in cc 1-20. This may be a maximum of 20 alphanumeric characters.

5. One card containing N in cc 1-2. N is the number of dosage groups for the assay. N must be an integer ≤ 50.

6. N cards containing the following information for each group:

   cc 1-3, D (The dosage level);
   cc 4-8, R (The no. of subjects reacting);
   cc 9-16, EN (the no. of subjects in the group).

   All three values must be in floating-point, F-type notation.

The data for any number of assays (4,5,6 above) may follow.

OUTPUT: The format of the typed output is shown with the sample problem. The typewriter is programmed to space to a new page before beginning the next assay. Card output is an exact duplicate of typewriter output including blank cards within the body of the problem (but not the page spacing at the end) so that an 80-80 listing on the 407 will produce the same format as the typed output.

SAMPLE INPUT

```
.22583680  .25212870 1.25969510 1.28782250  .94064610
 6
 1.  2.6737
16.  4.0055
30.  4.4756
50.  5.0000
84.  5.9945
99.  7.3263
PROBIT EXAMPLE 1
 4
 5.   1.     10.
10.   3.     10.
25.   8.     10.
50.  10.     10.
PROBIT EXAMPLE 2
 5
 1.   1.     10.
 5.   1.      8.
10.   1.      4.
25.  10.     20.
50.  35.     40.
PROBIT EXAMPLE 3
 5
35.   9.     10.
20.  14.     20.
10.   4.      8.
 5.   6.     20.
 1.   2.     10.
PROBIT EXAMPLE 4
 5
1.0   1.     10.
1.5   4.     20.
2.0  10.     40.
5.0   6.     10.
10.   5.      5.
```


PROBIT EXAMPLE 1

PROBIT = +1.119 +3.458LOG DOSE

D.F.	CHI-SQUARE
+2	+.4792

95 PER CENT CONFIDENCE LIMITS (NON-SIG. CHI-SQ.)

P	LOG ED(P)	LOWER	UPPER	ED(P)	LOWER	UPPER
+1.	+.4493431	+.0893390	+.8093472	+2.8141	+1.2283	+6.4468
+16.	+.8344083	+.6291276	+1.0396891	+6.8298	+4.2572	+10.9569
+30.	+.9703290	+.8036265	+1.1370315	+9.3396	+6.3624	+13.7098
+50.	+1.1219495	+.9737812	+1.2701178	+13.2418	+9.4141	+18.6259
+84.	+1.4094907	+1.2086184	+1.6103630	+25.6738	+16.1665	+40.7720
+99.	+1.7945559	+1.4404166	+2.1486952	+62.3097	+27.5687	+140.8300

PROBIT EXAMPLE 2

PROBIT = +3.015 +1.679LOG DOSE

D.F.	CHI-SQUARE
+3	+6.0823

95 PER CENT CONFIDENCE LIMITS (NON-SIG. CHI-SQ.)

P	LOG ED(P)	LOWER	UPPER	ED(P)	LOWER	UPPER
+1.	-.2035168	-.9502609	+.5432272	+.6258	+.1121	+3.4932
+16.	+.5896205	+.1790390	+1.0002019	+3.8870	+1.5102	+10.0046
+30.	+.8695828	+.5659155	+1.1732502	+7.4059	+3.6805	+14.9021
+50.	+1.1818830	+.9707824	+1.3929836	+15.2013	+9.3493	+24.7163
+84.	+1.7741454	+1.5233253	+2.0249655	+59.4491	+33.3676	+105.9169
+99.	+2.5672828	+2.0100974	+3.1244682	+369.2179	+102.3522	+1331.8895

PROBIT EXAMPLE 3

PROBIT = +3.767 +1.352LOG DOSE

D.F.	CHI-SQUARE
+3	+2.1531

95 PER CENT CONFIDENCE LIMITS (NON-SIG. CHI-SQ.)

P	LOG ED(P)	LOWER	UPPER	ED(P)	LOWER	UPPER
+1.	-.8086213	-1.8001502	+.1829074	+.1553	+.0158	+1.5237
+16.	+.1761488	-.3140370	+.6663347	+1.5001	+.4852	+4.6380
+30.	+.5237539	+.1859431	+.8615647	+3.3400	+1.5344	+7.2705
+50.	+.9115099	+.6724800	+1.1505399	+8.1566	+4.7041	+14.1429
+84.	+1.6468711	+1.2090628	+2.0846794	+44.3477	+16.1831	+121.5288
+99.	+2.6316413	+1.6992081	+3.5640745	+428.1947	+50.0274	+3665.0043

PROBIT EXAMPLE 4

PROBIT = +3.585 +2.658LOG DOSE

D.F.	CHI-SQUARE
+3	+1.0789

95 PER CENT CONFIDENCE LIMITS (NON-SIG. CHI-SQ.)

P	LOG ED(P)	LOWER	UPPER	ED(P)	LOWER	UPPER
+1.	-.3429391	-.7032123	+.0173341	+.4540	+.1980	+1.0407
+16.	+.1580888	+.0127159	+.3034616	+1.4390	+1.0297	+2.0112
+30.	+.3349421	+.2211101	+.4487741	+2.1624	+1.6638	+2.8104
+50.	+.5322233	+.3824933	+.6819532	+3.4058	+2.4126	+4.8078
+84.	+.9063578	+.5994673	+1.2132482	+8.0604	+3.9761	+16.3398
+99.	+1.4073858	+.8590527	+1.9557189	+25.5497	+7.2285	+90.3064

OPERATING INSTRUCTIONS

1. Set Console Switches

CONSOLE SWITCH	ON	OFF
1	Program pauses after each assay; push start to continue	Program runs continuously; no last card test
2	Punched output	Typed output
3	Not used	
4	Not used	

2. For typed output, typewriter margins must be set to allow for at least 80 characters. No tab stops are necessary. Set to double space.

3. Set parity and I/O switches to stop, overflow switch to program.

4. Clear Storage:

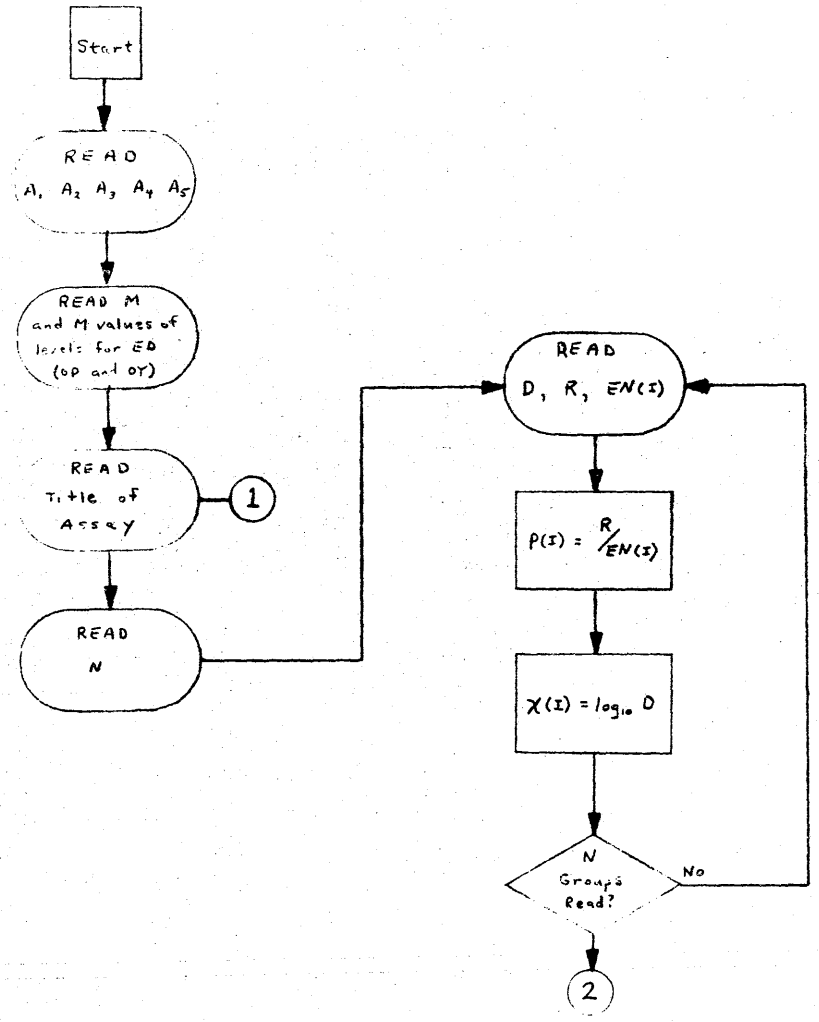
   a. Press reset
   b. Press insert
   c. Type 1600010 00000
   d. Press release and start
   e. When clear, press instant stop
   f. Press reset

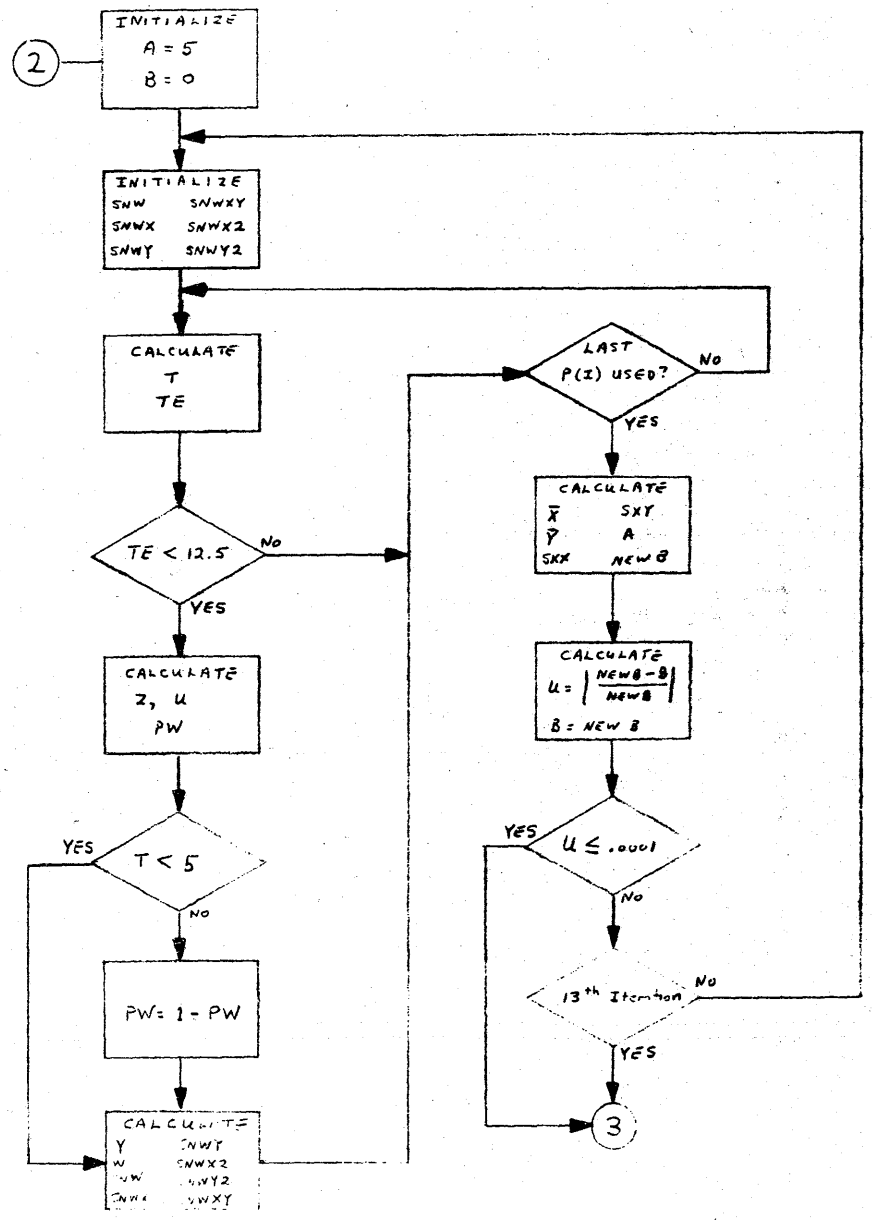
5. Place program deck in card reader, press load.

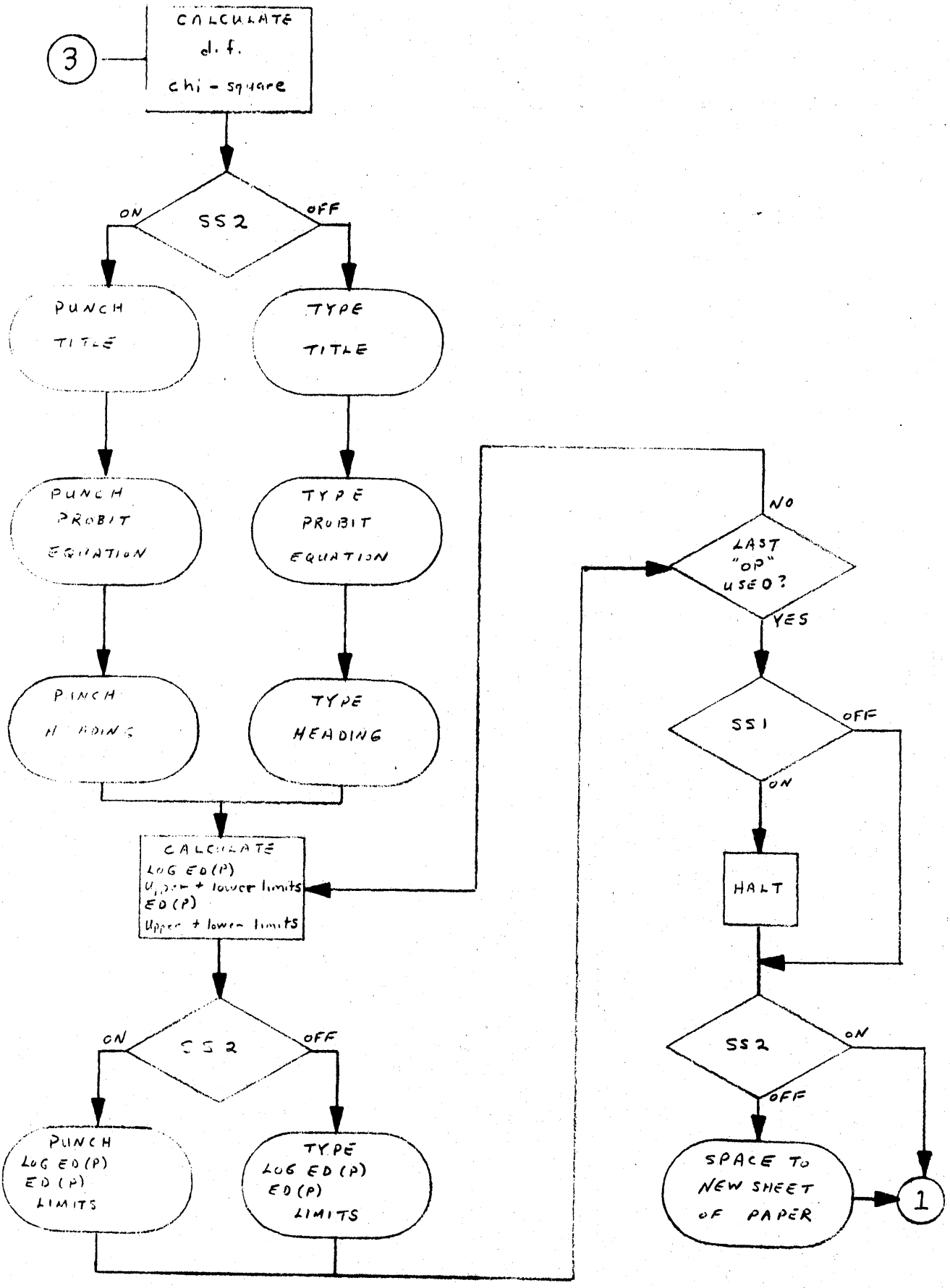
6. When program is loaded, message "load data" will be typed. Place data package in card reader, press Reader Start and and Console Start . (If desired, the data may be placed directly behind the program when program is loaded. When "Load data" is typed, press Console Start only).

7. If a number of assays are to be run switch 1 may be left off and turned on as last assay starts. If switch 1 is off when reader runs out of cards, machine will hang up with reader no feed light on.

8. If it is desired to change values of OP between assays, the reader must be emptied of cards and the complete data package as described in Input data section placed in reader. Press reset, insert, type 49 08300, release and start.


Start
READ
A1 A2 A3 A4 A5
READ M
and M values of
levels for ED
(op and oy)
READ
Title of
Assay
1
READ
N
READ
D, R, EN(I)
P(I) = R/EN(I)
X(I) = log10 D
N
Groups
Read?
No
2


2
INITIALIZE
A = 5
B = 0
INITIALIZE
SNW SNWXY
SNWX SNWX2
SNWY SNWY2
CALCULATE
T
TE
TE < 12.5
No
YES
CALCULATE
Z, U
PW
YES
T < 5
No
PW = 1 - PW
CALCULATE
Y SNWT
W SNWX2
NW SNWY2
SNWX SNWXY
LAST
P(I) USED?
No
YES
CALCULATE
X̄ SXY
Ȳ A
SXX NEW B
CALCULATE
U = |(NEW B - B)/NEW B|
B = NEW B
YES
U ≤ .0001
No
13th Iteration
No
YES
3


3
CALCULATE
d. f.
chi - square
SS 2
ON
OFF
PUNCH
TITLE
TYPE
TITLE
PUNCH
PROBIT
EQUATION
TYPE
PROBIT
EQUATION
PUNCH
HEADING
TYPE
HEADING
CALCULATE
LOG ED(P)
Upper + lower limits
ED(P)
Upper + lower limits
SS 2
ON
OFF
PUNCH
LOG ED(P)
ED(P)
LIMITS
TYPE
LOG ED(P)
ED(P)
LIMITS
NO
LAST
"OP"
USED?
YES
SS 1
OFF
ON
HALT
SS 2
ON
OFF
SPACE TO
NEW SHEET
OF PAPER
1

```
08300 C       PROBIT ANALYSIS
08300         DIMENSION X(50),P(50),OP(10),OY(10),EN(50)
08300         EPSLN = 1.E-4
08324         READ 100, A1, A2, A3, A4, A5
08396 100     FORMAT (F9.8, F11.8, F11.8, F11.8, F11.8)
08438         READ 101, M
08462 101     FORMAT (I2)
08484         DO 1 I = 1,M
08496 1       READ 102, OP(I), OY(I)
08616 102     FORMAT (F3.0,F8.4)
08644 2       READ 103,
08656 103     FORMAT (20H                    )
08720         READ 101, N
08744         DO 3 I = 1,N
08756         READ 104, D, R, EN(I)
08828 104     FORMAT (F3.0,F5.0,F8.0)
08860         P(I)=R/EN(I)
08944 3       X(I) = .43429448 * LOG(D)
09040         A = 5.
09064         B = 0.
09088         DO 4 J = 1,13
09100         SNW= 0.
09124         SNWX =0.
09148         SNWY=0.
09172         SNWXY=0.
09196         SNWX2=0.
09220         SNWY2=0.
09244         DO 5 I = 1,N
09256         T = A + B * X(I)
09328         TE = (T-5.)*(T-5.)*.5
09424         IF (TE-12.5) 6,5,5
09492 6       Z = .3989423  * EXP(-TE)
09552         U= 1./(1.+.23164189* ABS(T-5.))
09636 23      PW = ((((A5*U-A4)*U+A3)*U-A2)*U+A1)*U*Z *1.414214
09792 60      IF (T-5.)9,8,8
09860 8       PW = 1.-PW
09896 9       Y = T + (P(I)-PW)/Z
09980         W = Z*Z/(PW*(1.-PW)) *EN(I)
10112         SNW = SNW  + W
10148         SNWX = SNWX + W*X(I)
10220         SNWY = SNWY + W*Y
10268         SNWX2 = SNWX2 + W* X(I) * X(I)
10376         SNWY2 = SNWY2 + W*Y*Y
10436         SNWXY = SNWXY + W * X(I) * Y
10520 5       CONTINUE
10556         XBAR = SNWX/SNW
10592         YBAR = SNWY/SNW
10628         SXY = SNWXY - YBAR * SNWX
10688         SXX = SNWX2 - XBAR * SNWX
10748         BNXT = SXY / SXX
10784         A = YBAR - BNXT * XBAR
10844         U = ABS((BNXT-B)/BNXT)
10904         B = BNXT
10928         IF (U-EPSLN) 7,7,4
10996 4       CONTINUE
```

```
T1032 7      N = N-2
T1068        CHI = SNWY2 - YBAR * SNWY - SXY * BNXT
T1176        W = 1. / SXX
T1212        SNW = 1. / SNW
T1248        Y  = 1./B
T1284        IF (SENSE SWITCH 2) 70, 71
T1304 70     PUNCH 103,
T1316        PUNCH 105, A, B,
T1352 105    FORMAT ( /8HPROBIT =F7.3,F7.3,8HLOG DOSE/)
T1436 106    FORMAT(25H D.F.          CHI-SQUARE/13,13XF8.4/)
T1564        PUNCH 106, N, CHI
T1600        PUNCH 107,
T1612 107    FORMAT(48H95 PER CENT CONFIDENCE LIMITS (NON-SIG. CHI-SQ.))
T1732        GO TO 72
T1740 71     TYPE 103,
T1752        TYPE 105, A, B
T1788        TYPE 106, N, CHI
T1824        TYPE 107,
T1836 72     U = HEAD(U)
T1860        DO 12 I = 1,M
T1872        D = (OY(I) - A ) * Y
T1944        R = D - XBAR
T1980        SX = Y  * SQRT(SNW+ R*R*W) * 1.96
T2076        DU = D + SX
T2112        DL = D - SX
T2148        DE = EXP (2.3025851*D)
T2196        DUE = EXP (2.3025851*DU)
T2244        DLE = EXP (2.3025851*DL)
T2292        IF (SENSE SWITCH 2) 80, 81
T2312 80     PUNCH 109, OP(I), D, DL, DU, DE, DLE, DUE
T2432 109    FORMAT(F4.0, F13.7, F13.7, F13.7, F12.4, F12.4, F12.4)
T2484        GO TO 12
T2492 81     TYPE 109, OP(I), D, DL, DU, DE, DLE, DUE
T2612 12     CONTINUE
T2648        IF (SENSE SWITCH 1) 13, 35
T2668 13     PAUSE
T2680 35     IF (SENSE SWITCH 2) 37, 36
T2700 36     N = 15 - M
T2736        DO 30 I = 1, N
T2748 30     TYPE 110,
T2796 110    FORMAT (/)
T2818 37     GO TO 2
T2826        END
```


PROG SW 1 ONFOR SYMBOL TABLE, PUSH START

```
T9999 SIN
T9989 SINF
T9979 COS
T9969 COSF
T9959 ATAN
T9949 ATANF
T9939 EXP
T9929 EXPF
T9919 LOG
T9909 LOGF
T9899 SQRT
T9889 SQRTF
T9879 ABS
T9869 ABSF
T9859 HEAD
T9849 HEADF
T9839 X       T9349
T9339 P       T8849
T8839 OP      T8749
T8739 OY      T8649
T8639 EN      T8149
T8139 EPSLN
T8129 T000000003
T8119 0100
T8109 0100
T8099 A1
T8089 A2
T8079 A3
T8069 A4
T8059 A5
T8049 0101
T8039 0101
T8029 M
T8019 0001
T8009 I
T7999 0102
T7989 0102
T7979 0002
T7969 0103
T7959 0103
T7949 N
T7939 0003
T7929 0104
T7919 0104
T7909 D
T7899 R
T7889 000
T7879 4342944800
T7869 A
T7859 5000000001
T7849 B
T7839 0000000099
T7829 0004
T7819 J
T7809 SNW
T7799 SNWX
T7789 SNWY
T7779 SNWXY
T7769 SNWX2
T7759 SNWY2
```

```
T7749 0005
T7739 T
T7729 TE
T7719 001
T7709 003
T7699 5000000000
T7689 T250000002
T7679 0006
T7669 Z
T7659 3989423000
T7649 U
T7639 T000000001
T7629 Z316418900
T7619 0023
T7609 PW
T7599 004
T7589 T414214001
T7579 0060
T7569 0009
T7559 0008
T7549 Y
T7539 W
T7529 XBAR
T7519 YBAR
T7509 SXY
T7499 SXX
T7489 BNXT
T7479 0007
T7469 0002
T7459 CHI
T7449 0070
T7439 0071
T7429 0105
T7419 0105
T7409 0106
T7399 0106
T7389 0107
T7379 0107
T7369 0072
T7359 0012
T7349 SX
T7339 T960000001
T7329 DU
T7319 DL
T7309 DE
T7299 Z302585101
T7289 DUE
T7279 DLE
T7269 0080
T7259 0081
T7249 0109
T7239 0109
T7229 0013
T7219 0035
T7209 0037
T7199 0036
T7189 0015
T7179 0030
T7169 0110
T7159 0110

SW 1 OFF TO IGNORE SUBROUTINES, PUSH START

PROCESSING COMPLETE
```


ABSOLUTE VALUE SUBROUTINE - ABS

```
        DORG    5000                    05000
        TD      *+19, MEM,0             05000   25      05019   00400
        TF      *+23, 19989-20 *N,0     05012   26      05035   19869
        TF      FAC, *-*                05024   26      00060   00000
        TF      *+35, *-1, 01           05036   26      05071   05035
        SM      *+23, 2, 010            05048   12      05071   00002
        TF      FAC-2, *-*              05060   26      00058   00000
        CF      FAC-2                   05072   33      00058   00000
        BB                              05084   42      00000   00000
FAC     DS      ,60                     00060   00000
MEM     DS      ,400                    00400   00000
NN      DS      ,7                      00007   00000
N       DS      ,NN-1                   00006   00000
        DEND
```

If ABS is not the seventh subroutine in the FORTRAN subroutine deck, the symbol NN must be redefined appropriately.

```
        DORG    5000                    05000
        BC2     PUNCH,,0                05000  46  05044  00200
        RCTY                            05012  34  00000  00102
        WATY    HDNG,,0                 05024  39  05071  00100
        B       STFLG,,0                05036  49  05068  00000
        DORG    *-3                     05044
PUNCH   WACD    HDNG,,0                 05044  39  05071  00400
STFLG   SF      51                      05056  32  00051  00000
        BB                              05068  42  00000  00000
        DORG    *-9                     05070
HDNG    DAC     40,  P   LOG ED (P)       LOWER        UPPER
                                        05071  40 x 2
        DAC     41,      ED (P)         LOWER        UPPER   @
                                        05151  41 x 2
        DEND
```

If the program is recompiled for a paper tape machine, the instruction at 05044 must be changed to 39 05071 00200.

ABS - 7th Subroutine

```
10                                                                  0   10000
250501900400 260503519869 260006000000 260507105035 120507100002 +0010500005060010001
260005800000 330005800000 42+                                       0010506005086010002
00086                                                               0   10003
```

HEAD - 8th Subroutine

```
11                                                                  0   11000
460504400200 340000000102 390507100100 490506800000 +               0  0500005048011001
390507100400 320005100000 420000000000 +                            0  0504405080011002
000057000000 005356470045 442457040000 000000005356 664559000000 +1  0507005130011003
000000000064 575745590000 000000000045 442457040000 000000000000 +1  0513005190011004
535666455900 000000000000 645757455900 0000+                        1  0519005230011005
00230                                                               0   11006
```