TITLE: Probit Analysis by Maximum Likelihood

AUTHOR: Richard A. Lamm
Lederle Laboratories
Pearl River, New York

DATE: April 20, 1959

ABSTRACT:

DISCLAIMER:

"The authors of the program material, the POOL organization and Royal McBee believe this program to be correct; however, they bear no responsibility, financial or otherwise, for errors resulting from its use. This program is distributed only to individual and installation members of POOL. Further distribution of this manual and accompanying tapes for use by non-members is prohibited."

Program Number: F6-107
April 20, 1959

TITLE: Probit Analysis by Maximum Likelihood

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Purpose: To fit the log-normal tolerance distribution with quantal responses by maximum likelihood.

Restrictions:

a. The total number of objects exposed (Σ n) should not exceed 6400. If the number is greater, the confidence limits on the log ED_{50}, m, and the ED_{50} will be incorrect. Other output should be correct.

b. At least two r_i must be partial responses, i.e., for at least two doses $0 < r_i / n_i < 1$.

c. Program uses normal deviates (t = Probit -5) rather than probits. Therefore, probit intercept, a, is coded by -5.

d. If the magnitude of the expected t is greater than 5, the probit weight (w) is set equal to zero. Its actual value is less than 0.00000771.

e. The probit slope, b, is iterated to 3 decimal digit accuracy (11 binal places) or until 12 cycles of iteration are completed, if the slope does not converge in fewer cycles. This accuracy may be altered by changing the b mask in Lo + 0654 or by extending the cycles by changing the maximum cycle test in Lo + 0540.

f. Subroutines Required:

Routine	Code	Lo
Data Input No. 3	11.2	0300
Data Output No. 2	12.1	1300
Alphanumeric	19.0	1900
Square Root	15.0	1600
Log_k X	18.0	1700
Exponential	17.0	2300
Antilog Printout	LED-21	2100

The program is stored in Lo to Lo + 0715. Data is loaded in Lo + 0716 to Lo + 0719 + 3N, where N is the number of data triplets (d,n,r).

METHOD:

The method outlined in D.J. Finney: Probit Analysis, Cambridge University Press is used in this program. The notation used in the program does not always follow that of the text, but an appendix of notation equivalents is included at the end of this "writeup". An initial estimation of a = 0, b = 0 is used in the iteration.

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

by a modification of a formula appearing in Hastings:

Approximations for Digital Computers. The approximation is:

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

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

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

$a_1 = 0.2258368\,46$, $a_2 = -0.252128668$

$a_3 = 1.259695130$, $a_4 = -1.287822453$

$a_5 = 0.940646070$, $q = 0.2316418883$

CODING INFORMATION:

a. Storage. Program: 7 tracks plus 16 sectors (Lo to Lo + 0715)

Intermediate and Final Results: 6320 to 6324, 6331 to 6363.

Data: As required - Lo + 0716 to Lo + 0719 + 3N

b. Program Start. Lo

c. Input. Data tape includes for each assay

1. Compound name or number followed by a cond. stop.

2. 0 + 29 (Lo + 0716)'N'q_d'q_n'L'-0000000'
where N is the number of data triplets (d_i,n_i,r_i)
q_d is the q at which doses are entered
(as required)

q_n	4	6	8	10	12
if Σn	0-25	26-100	101-400	401-1600	1601-6400

provided no n_i exceeds 2^{q_n}. If so, use the next higher even q.

L = 0 if not the last assay.
= 1 for the last assay.

3. $P+q_d$ (Lo + 0720)'d_1'd_2' ...'d_N'-0000000'

4. $0+q_n$ (Lo + 0720 + N)'n_1'n_2' ...' n_N'-0000000'

5. $0+(q_n+1)$(Lo + 0720 + 2N)'r_1'r_2' ...' r_N'-0000000''

d. Output. (See Example)

e. Constants. Most constants are located in Lo + 0645 to Lo + 0711. Those which may require alteration according to needs are:

Maximum cycle counter	(12 @ 29)	Lo + 0540
Slope accuracy mask	(wwww0000)	Lo + 0654
Magnitude of $t^2/2$ test	(12.5 @ 8)	Lo + 0652*

f. Timing. This varies according to many factors. We have found the average time to be 2.5 - 3.5 minutes per assay.

g. Erasable Memory Locations. Anything outside of Lo to Lo + 0715 and the required subroutines.

h. Program Stops. Lo + 0063 or Lo + 0100 indicates poor data, i.e.

$|(p-P)/Z|$ or $|t + (p-P)/Z| \geq 16.$

Lo + 0200 $|b| \geq 16.$
Lo + 0534 - calculations completed.

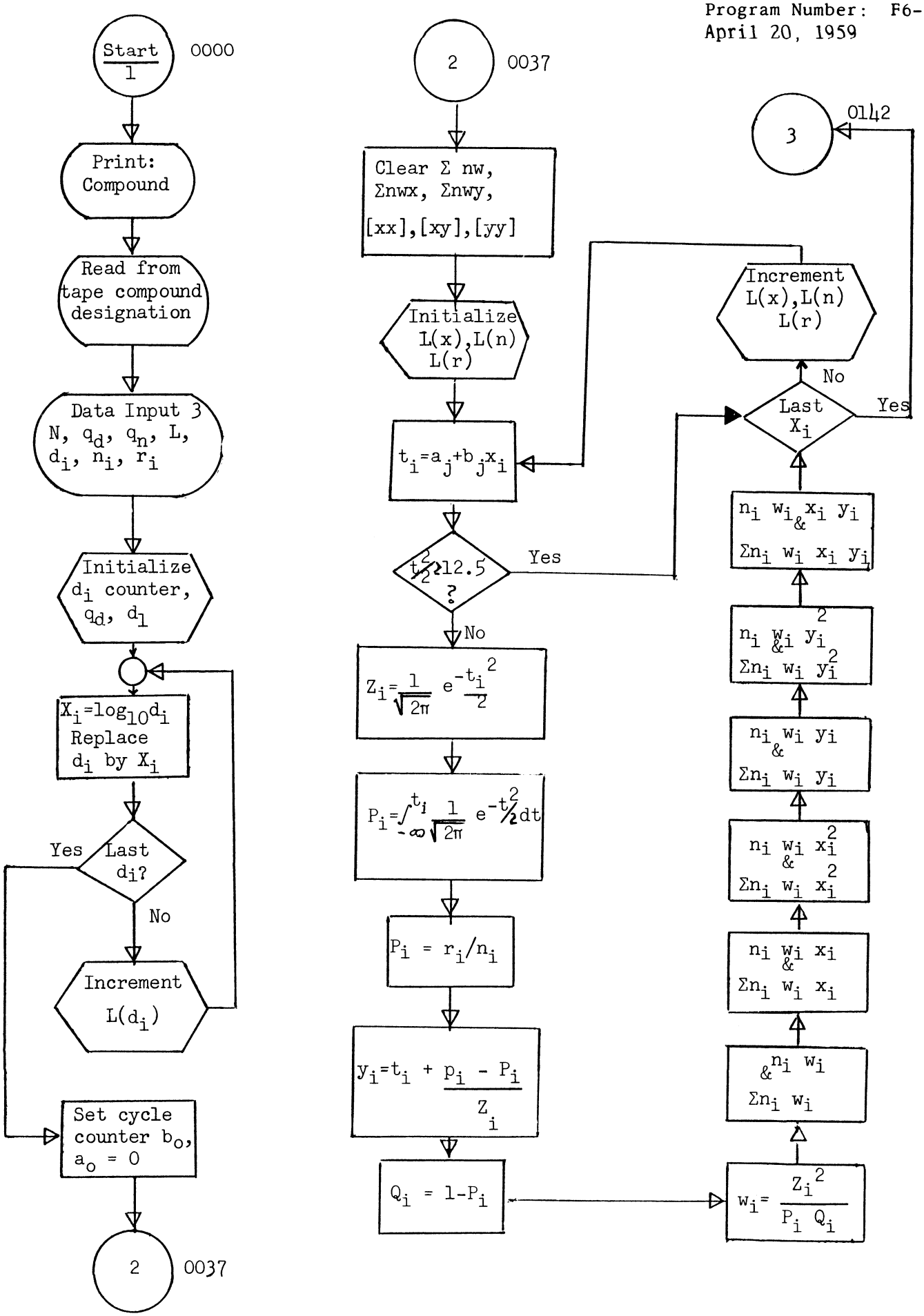
i. Format: Set CR at 1 and Tabs at 11, 21, 31 with no automatic CR in this range.

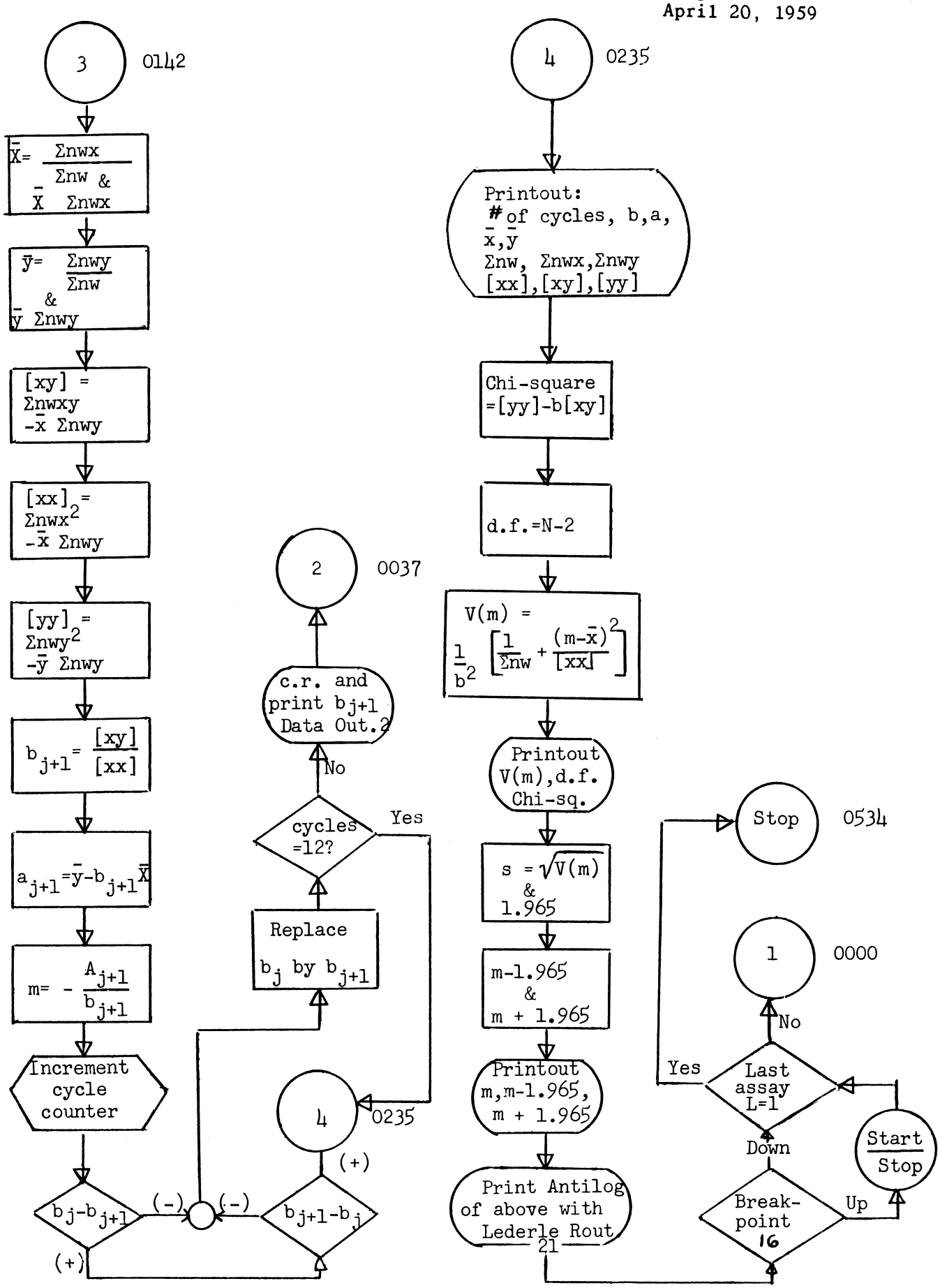
j. Breakpoint 16 (Lo + 0530).
UP - Stop after each assay.
DOWN - No stop until the last assay is completed.

*If this is enlarged to encompass higher integers, ie. I = 13, etc. further values of $\frac{1}{\sqrt{2\pi}} e^{-I}$ must be included in Lo + 0712 ... .

Notation Changes

D.J. Finney	Program	Remarks
λi	d_i	i th dose
Y	t	Expected probit t = Y - 5
a	a	a of program is Finney's a - 5
Snw	Σnw	Sum of weights
$Snw(x-\bar{x})^2$	[xx]	Sum of weighted squared deviations from mean
k	N	Number of data triplets (d,n,r)
s_m	s	Standard error of m (Log ED_{50})
y_i	y_i	Working probit. Coded same as a in program.


Start 1
0000
Print: Compound
Read from tape compound designation
Data Input 3
N, q_d, q_n, L, d_i, n_i, r_i
Initialize d_i counter, q_d, d_1
$X_i = \log_{10} d_i$
Replace d_i by X_i
Yes
Last d_i?
No
Increment $L(d_i)$
Set cycle counter b_o, a_o = 0
2
0037
2
0037
Clear Σ nw, Σnwx, Σnwy, [xx], [xy], [yy]
Initialize L(x), L(n) L(r)
$t_i = a_j + b_j x_i$
$t_i^2/2 \geq 12.5$?
Yes
No
$Z_i = \frac{1}{\sqrt{2\pi}} e^{-t_i^2/2}$
$P_i = \int_{-\infty}^{t_i} \frac{1}{\sqrt{2\pi}} e^{-t^2/2} dt$
$P_i = r_i / n_i$
$y_i = t_i + \frac{p_i - P_i}{Z_i}$
$Q_i = 1 - P_i$
$w_i = \frac{Z_i^2}{P_i Q_i}$
$\&^{n_i w_i}_{\Sigma n_i w_i}$
$\&^{n_i w_i x_i}_{\Sigma n_i w_i x_i}$
$\&^{n_i w_i x_i^2}_{\Sigma n_i w_i x_i^2}$
$\&^{n_i w_i y_i}_{\Sigma n_i w_i y_i}$
$\&^{n_i w_i y_i^2}_{\Sigma n_i w_i y_i^2}$
$\&^{n_i w_i x_i y_i}_{\Sigma n_i w_i x_i y_i}$
Last X_i
No
Yes
Increment L(x), L(n) L(r)
3
0142


3
0142
$\bar{X}=\frac{\Sigma nwx}{\Sigma nw}$ & $\bar{X}\ \Sigma nwx$
$\bar{y}=\frac{\Sigma nwy}{\Sigma nw}$ & $\bar{y}\ \Sigma nwy$
$[xy]=\Sigma nwxy-\bar{x}\ \Sigma nwy$
$[xx]=\Sigma nwx^2-\bar{x}\ \Sigma nwy$
$[yy]=\Sigma nwy^2-\bar{y}\ \Sigma nwy$
$b_{j+1}=\frac{[xy]}{[xx]}$
$a_{j+1}=\bar{y}-b_{j+1}\bar{X}$
$m=-\frac{A_{j+1}}{b_{j+1}}$
Increment cycle counter
b_j-b_{j+1}
(+)
(-)
(-)
$b_{j+1}-b_j$
(+)
4
0235
Replace b_j by b_{j+1}
cycles =12?
No
Yes
2
0037
c.r. and print b_{j+1} Data Out.2
4
0235
Printout: # of cycles, b,a, $\bar{x},\bar{y}$ Σnw, Σnwx, Σnwy [xx],[xy],[yy]
Chi-square =[yy]-b[xy]
d.f.=N-2
$V(m)=\frac{1}{b^2}\left[\frac{1}{\Sigma nw}+\frac{(m-\bar{x})^2}{[xx]}\right]$
Printout V(m),d.f. Chi-sq.
$s=\sqrt{V(m)}$ & 1.965
m-1.965 & m + 1.965
Printout m,m-1.965, m + 1.965
Print Antilog of above with Lederle Rout 21
Stop
0534
1
0000
No
Yes
Last assay L=1
Down
Break-point 16
Up
Start
Stop

PREPARED FOR: LGP-30 RPC-4000 USERS' ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. F6-107 ~~LEDERLE 20~~

PROGRAM PREPARED BY: R. A. LAMM

PROGRAM CHECKED BY: R.A.L.

DATE REV. 4/20/59

PROBLEM: PROBIT ANALYSIS - MAXIMUM LIKELIHOOD

TRACK 00

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0000	xR1900		·		} ALPHANUMERIC (19.0)
		01	xU1900		·		
,00000004	'	02	20202010		·		
		03	6F08463F		·	☒	
		04	42465232		·		"COMPOUND"
		05	2F06VQ00		·		
		06	xP0000		·		} PRINT COMPOUND #
		07	xI0000		·	☒	} FROM DATA TAPE
		08	xR0308		·		{ DATA INPUT #3
		09	xU0300		·		{ (SEE FRONT SHEET
		10	B0531		·	B0719	{ FOR FORMAT)
		11	A0716		·	☒ N@29	
		12	Y0032		·		
		13	B0717		·	q_d @29	
		14	Y0022		·		
		15	B0531		·	☒ B0719	
		16	A0229		·	1@29	
		17	Y0019		·		
		18	Y0025		·		
		19	B[ ]		·	☒ d_-@q_d	
		20	xR1724		·		} $\text{LOG}_{10} d_i$
		21	xU1700		·		
		22	Z[0041]		·		} (18.0)
		23	xZ0002		·	☒	
		24	D0646		·	1@2	→ $\log q_i = x_i$ @4
		25	C[ ]		·		
		26	B0019		·		
		27	S0032		·	☒	
		28	T0030		·		
		29	U0033		·		
		30	B0019		·		
		31	U0016		·	☒	

CONVERT DOSE, TO LOG-DOSE = X_i

LPR 5124-1

SC 0502

☒ CARRIAGE RETURN

· = CONDITIONAL STOP CODE

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JOB NO.

PROGRAM NO. ~~LED. 20~~ F6-107

PROGRAM PREPARED BY: R.A.L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 00

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	.						
	.	☒					
		0032	B[ ]		.		TEST FOR LAST d_i
		33	X	C6361	.		
		34	X	C6361	.		CYCLE COUNTER = 0
		35	X	C6362	.	☒	$b_0 = 0$
		36	X	C6363	.		$a_0 = 0$
		37	X	C6358	.		$\Sigma nw = 0$
		38	X	C6359	.		$\Sigma nwx = 0$
		39	X	C6360	.	☒	$\Sigma nwy = 0$
		40	X	C6355	.		$[xx] = 0$
		41	X	C6356	.		$[xy] = 0$
		42	X	C6357	.		$[yy] = 0$
		43	B	0531	.	☒ B0719	
		44	A	0229	.	1 @ 29	
		45	Y	0051	.		
		46	A	0716	.	N @ 29	
		47	Y	0060	.	☒	
		48	Y	0110	.		
		49	A	0716	.	N @ 29	
		50	Y	0059	.		
		51	B[ ]		.	☒ x_i @ 4	
		52	X	H6353	.		TEMP. STORE IN $\bar{X}$ LOC.
		53	X	M6362	.		→ bx_i @ 8
		54	X	A6363	.		→ $a + bx_i = t_i$ @ 8
		55	D	0648	.	☒ 1 @ 4	
		56	X	H6346	.		
		57	R	0636	.		} P, Z ROUTINE
		58	U	0544	.		
		59	B[ ]		.	☒ r_i @ q_{n+1}	
		60	D[ ]		.	n_i @ q_n → p @ 1	
		61	X	S6345	.	P @ 1	
		62	M	0647	.	1 @ 3	
		63	X	D6344	.	☒ Z @ 0	

LPR 5124-2

ROYAL MCBEE, ATHENS, O. H6726 X

☒ CARRIAGE RETURN

. = CONDITIONAL STOP CODE

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JOB NO.

PROGRAM NO. ~~LED 20~~ F6-107

PROGRAM PREPARED BY: R.A.L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 01

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·				·		
	·	☒			·		
		0100	x	A63446	·		} WORKING PROBIT -5
		0101	x	H63544	·		} @4, TEMP. STORE IN $\bar{y}$ LOC.
		0102		B06445	·	1@1	
		0103	x	S63445	·	☒ → Q @1	
		0104	x	M63445	·		
		0105		D06446	·	1@2	
		0106	x	C63244	·	TEMP. STORE PQ @0	
		0107	x	B63444	·	☒ Z @0	
		0108	x	M63444	·		
		0109	x	D63244	·	→ w @0	
		0110		M[ ]	·	n_i @ q_n	
		0111	x	H63244	·	☒	
		0112	x	A63588	·		
		0113	x	C63588	·	$\Sigma n_i w_i$ @q_n	
		0114	x	B63244	·		
		0115	x	M63533	·	☒ x_i @4	
		0116	x	H63233	·		
		0117	x	A63599	·		
		0118	x	C63599	·	$\Sigma n_i w_i x_i$ @ q_n+4	
		0119	x	B63233	·	☒	
		0120	x	M63533	·		
		0121	x	A63555	·		
		0122	x	C63555	·	$\Sigma n_i w_i x_i^2$ @ q_n+8	
		0123	x	B63244	·	☒	
		0124	x	M63544	·		
		0125	x	H63222	·		
		0126	x	A63600	·		
		0127	x	C63600	·	☒ $\Sigma n_i w_i y_i$ @ q_n+4	
		0128	x	B63222	·		
		0129	x	M63544	·		
		0130	x	A63577	·		
		0131	x	C63577	·	☒ $\Sigma n_i w_i y_i^2$ @ q_n+8	

LPR 5124-1

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☒ CARRIAGE RETURN

· = CONDITIONAL STOP CODE

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JOB NO. | PROGRAM NO. ~~LED 20~~ F6-107 | PROGRAM PREPARED BY: R.A.L | PROGRAM CHECKED BY: POOL Review | DATE 4-20-59

PROBLEM: PROBIT ANALYSIS | TRACK 01

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		01 32	xB	63223	·		
		33	xM	63544	·		
		34	xA	63566	·		
		35	xC	63566	·	☒ $\Sigma n_i w_i x_{ij}$ @	q_n+8
		36	B	00511	·		
		37	S	00322	·		
		38	T	01400	·		
		39	U	01422	·	☒ ⟶	LAST x_i, PROCEED CALC
		40	B	00511	·		
		41	U	00444	·	⟶	COMPUTE FOR NEXT x_i
		42	xB	63599	·	Σnwx @	q_n+4
		43	xD	63588	·	☒ Σnw @	q_n
		44	xH	63533	·	$\bar{x}$ @	4
		45	xM	63599	·		
		46	xC	63200	·	$\bar{x}\,\Sigma nwx$ @	q_n+8
		47	xB	63600	·	☒ Σnwy @	q_n+4
		48	xD	63588	·		
		49	xH	63544	·	$\bar{y}$ @	4
		50	xM	63600	·		
		51	xC	63211	·	☒ $\bar{y}\,\Sigma nwy$ @	q_n+8
		52	xS	63600	·		
		53	xM	63533	·		
		54	xA	63566	·		
		55	xC	63566	·	☒ $[xy] = \Sigma nwxy - \bar{x}\Sigma nwy$ @	q_n+8
		56	xB	63555	·		
		57	xS	63200	·		
		58	xC	63555	·	$[xx]$ @	q_n+8
		59	xB	63577	·	☒	
		60	xS	63211	·		
		61	xC	63577	·	$[yy]$ @	q_n+8
		62	xB	63566	·		
		63	M	06488	·	☒ 1 @	4

LPR 5124-2

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☒ CARRIAGE RETURN

· = CONDITIONAL STOP CODE

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JOB NO

PROGRAM NO. ~~LED 20~~ F6-107

PROGRAM PREPARED BY: R A L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 01

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0200	xD	6355	·		→ b_{j+1} @ 4
		01	E	0654	·	WWWW0000	
		02	xH	6343	·		
		03	xM	6353	·	☒	
		04	xC	6342	·	b_{j+1} $\bar{x}$ @ 8	
		05	xB	6354	·	$\bar{j}$ @ 4	
		06	M	0648	·	..1 @ 4	
		07	xS	6342	·	☒	
		08	xC	6363	·	a_{j+1} @ 8	
		09	xS	6363	·		
		10	xD	6343	·		
		11	xC	6350	·	☒ m_v = Log, ED50 @ 4	
		12	xB	6361	·		INCREMENT CYCLE COUNTER
		13	A	0229	·	1 @ 29	
		14	xC	6361	·		
		15	xB	6362	·	☒ b_j @ 4	
		16	xS	6343	·	b_{j+1} @ 4	
		17	T	0222	·	→	$b_{j+1} \neq b_j$
		18	xB	6343	·		
		19	xS	6362	·	☒	
		20	T	0222	·	→	$b_{j+1} \neq b_j$
		21	U	0235	·		$b_{j+1} = b_j$; TO OUTPUT
		22	xB	6343	·		REPLACE b_j by b_{j+1}
		23	xC	6362	·	☒	
		24	xB	6361	·		
		25	S	0540	·		
		26	T	0228	·		
		27	U	0235	·	☒ ↓ →	CYCLES = 12; TO OUTPUT
		28	xP	1600	·	<12	
		29	xZ	0001	·		
		30	xB	6343	·		
		31	xR	1305	·	☒	DATA OUTPUT #2

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☒ CARRIAGE RETURN

· CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. ~~LED 20~~ F6-107

PROGRAM PREPARED BY: R A L

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 02

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	.						
	.	☒					
		02 32	x U 1 3 0 0		.		} PRINT b FOR
		33	x Z 0 1 0 4		.		} CYCLE
		34	U 0 7 1 4		.	→ CLEAR Acc., START NEW ITERATION	
		35	x R 1 9 0 0		.	☒	ALPHANUMERIC OUTPUT
		36	x U 1 9 0 0		.		(19.0)
)0 0 0 0 0 0 7	'	37	2 0 1 8 6 F 1 2		.		
		38	6 F 0 J 4 F 7 F		.		"CYCLES" "SLOPE."
		39	3 0 7 F 0 J 4 6		.	☒	"INTERCEPT"
		40	4 2 4 F 3 0 2 2		.		
		41	3 2 5 F 4 F 1 F		.		
		42	6 F 4 F 4 2 5 F		.		
		43	2 0 1 8 V Q 0 0		.	☒	
		44	x B 6 3 6 1		.		
		45	x K 1 3 0 5		.		}
		46	x U 1 3 0 0		.		} DATA
		47	x Z 0 1 2 9		.	☒	} OUTPUT #2
		48	x Z 0 1 0 4		.		} (12.1)
		49	x Z 0 1 0 8		.		}
		50	x R 1 9 0 0		.		} ALPHA NUMERIC
		51	x U 1 9 0 0		.	☒	} (19.0)
)0 0 0 0 0 0 5	'	52	2 0 2 0 1 8 1 0		.		
		53	3 0 0 A 3 0 0 A		.		$\bar{x}$ f
		54	2 0 0 8 3 0 4 A		.		
		55	3 0 1 2 2 0 1 8		.	☒	
		56	3 0 V Q 0 0 0 0		.		
		57	x B 6 3 5 3		.		
		58	x K 1 3 0 5		.		} DATA
		59	x U 1 3 0 0		.	☒	} OUTPUT #2
		60	x Z 0 2 0 4		.		} (12.1)
		61	x R 1 9 0 0		.		} ALPHA NUMERIC
		62	x U 1 9 0 0		.		} (19.0)
)0 0 0 0 0 0 7	'	63	2 0 2 0 1 8 1 0		.	☒	

LPR 5124-2

ROYAL MCBEE, ATHENS, O. H8262E

☒ CARRIAGE RETURN

. = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE
	~~LED 20~~ F6-107	R.A.L.	POOL Review	4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 03

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0300	4408327J	·			"Σ nw"
		01	30104408	·			"Σ nwx"
		02	327J4A30	·			"Σ nwy"
		03	10440832	·	☒		
		04	7J122018	·			
		05	VQ00000000	·			
		06	B0541	·		x Z0100	
		07	A0718	·	☒	qn @29	
		08	Y0315	·			
		09	B0260	·		x Z0204	
		10	A0718	·			
		11	Y0316	·	☒		
		12	xB6358	·			
		13	xR1305	·			} DATA OUTPUT #2 (12.1)
		14	xU1300	·			
		15	Z[0100+9n]	·	☒		
		16	Z[0204+9n]	·			
		17	xR1900	·			} ALPHANUMERIC (19.0)
		18	xU1900	·			
)0000007	'	19	20201810	·	☒		
		20	36084A4A	·			"[xx]"
		21	102A3036	·			"[xy]"
		22	084A1210	·			"[yy]"
		23	2A303608	·	☒		
		24	12121024	·			
		25	08201 8VQ	·			
		26	B0542	·		x Z0308	
		27	A0718	·	☒	qn @29	
		28	Y0332	·			
		29	xB6355	·			
		30	xR1305	·			} DATA OUTPUT #2 (12.1)
		31	xU1300	·	☒		

LPR 5124-1

ROYAL MCBEE, ATHENS, O. H0876228

☒ CARRIAGE RETURN

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PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. ~~LED-20~~ FC-107

PROGRAM PREPARED BY: R A. L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 03

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	.						
	.	☒					
		0 3 3 2	Z	[0308+q_n]	.		
		3 3	x B	6 3 6 2	.	b @ 4	
		3 4	x M	6 3 5 6	.	[xy] @ q_n+8	
		3 5	D	0 6 4 8	.	☒ 1 @ 4	
		3 6	x C	6 3 4 1	.		
		3 7	x B	6 3 5 7	.	[yy] @ q_n+8	
		3 8	x S	6 3 4 1	.		
		3 9	x C	6 3 4 9	.	☒ χ^2 (Chi-SQUARE) @ q_n+8	
		4 0	B	0 7 1 6	.	N @ 29	
		4 1	S	0 0 2 3	.	2 @ 29	
		4 2	x C	6 3 4 8	.	d.f. @ 29	
		4 3	x B	6 3 5 0	.	☒	
		4 4	x S	6 3 5 3	.		
		4 5	x H	6 3 4 0	.	$m - \bar{x}$ @ 4	
		4 6	M	0 6 5 0	.	1 @ 8	
		4 7	x D	6 3 5 5	.	☒ [xx] @ q_n+8	
		4 8	x M	6 3 4 0	.		
		4 9	x C	6 3 3 9	.	$(m-\bar{x})^2/[xx]$ @ 8 − q_n	
		5 0	B	0 6 5 0	.	1 @ 8	
		5 1	x D	6 3 5 8	.	☒ → $1/\Sigma nw$ @ 8 − q_n	
		5 2	x A	6 3 3 9	.		
		5 3	M	0 6 4 8	.	1 @ 4	
		5 4	x D	6 3 6 2	.	k @ 4	
		5 5	M	0 6 4 8	.	☒	
		5 6	x D	6 3 6 2	.		
		5 7	M	0 6 4 8	.		
		5 8	x C	6 3 4 7	.	V(m) @ 12 − q_n	
		5 9	x R	1 9 0 0	.	☒ } ALPHANUMERIC (19.0)	
		6 0	x U	1 9 0 0	.	}	
) 0 0 0 0 0 0 8	1	6 1	2 0 2 0	1 8 1 0	.		
		6 2	3 A 4 J	0 8 3 F	.		
		6 3	1 0 0 4	3 0 0 8	.	☒	

LPR 5124-2

ROYAL MCBEE, ATHENS, G. H626222

☒ CARRIAGE RETURN

. = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. FG-107 ~~LED 20~~

PROGRAM PREPARED BY: R.A.L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 04

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
	·	0400	2F	2A542A	·		"V(m)"
		01	30	106F08	·		"d.f."
		02	62	220A7F	·		"Chi-SQUARE"
		03	74	52721F	·	☒	
		04	4F	1820VQ	·		
		05		B0543	·	×Z0112	
		06		S0718	·	q_n @ 29	
		07		Y0414	·	☒	
		08		B0249	·	×Z0108	
		09		A0718	·		
		10		Y0416	·		
		11		×B6347	·	☒	
		12		×R1305	·		DATA OUTPUT #2 (12.1)
		13		×U1300	·		
		14		Z[0112-q_n]	·		
		15		×Z0129	·	☒	
		16		Z[0108+q_n]	·		
		17		×B6347	·		
		18		×R1650	·		SQUARE ROOT (15.0)
		19		×U1600	·	☒	
		20		M0653	·	1.96 @ 1	→ 1.96 S @ 7 - (q_n/2)
		21		×C6338	·		
		22		S0718	·	q_n @ 29	
		23		M0645	·	☒ .5 @ 0 or 1 @ 1	
		24		A0534	·	7 @ 29	
		25		S0023	·	2 @ 29	
		26		T0444	·	.(-) →	7 - (q_n/2) = 1
		27		S0229	·	☒ 1 @ 29	
		28		T0441	·		= 2
		29		S0229	·		
		30		T0438	·		= 3
		31		S0229	·	☒	

LPR 5124-1

ROYAL MCBEE, ATHENS, O. M036272E

☒ CARRIAGE RETURN

· = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. F6-107 ~~LED 20~~

PROGRAM PREPARED BY: R.A.L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 04

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0432	T	0436	·		(−) → 7−(9+L) = 4 (+) → = 5
		33	x B	6338	·		
		34	D	0645	·	1@1	
		35	U	0446	·	☒	
		36	x B	6338	·		
		37	U	0446	·		
		38	x B	6338	·		
		39	M	0645	·	☒ 1@1	
		40	U	0446	·		
		41	x B	6338	·		
		42	M	0646	·	1@2	
		43	U	0446	·	☒	
		44	x B	6338	·		
		45	M	0647	·	1@3	
		46	x H	6337	·	1.96 S @4	
		47	x A	6350	·	☒	
		48	x C	6352	·	m+1.96 S @4	
		49	x B	6350	·		
		50	x S	6337	·		
		51	x C	6351	·	☒ m−1.96 S	@4
		52	x R	1900	·		} ALPHANUMERIC (19.0)
		53	x U	1900	·		
)00000020	'	54	2020	1830	·		
		55	4J2J	102J	·	☒	
		56	0806	6F46	·		"95% CONFIDENCE
		57	3254	222F	·		LIMITS (NON SIG.
		58	4F32	6F4F	·		Chi-Sq.)"
		59	060J	223F	·	☒	
		60	225F	7F06	·		
		61	104J	0832	·		"LOG ED50"
		62	4632	0A7F	·		"LOWER"
		63	225J	2A06	·	☒	"UPPER"

LPR 5124-2

ROYAL MCBEE, ATHENS, O. H6868BB

☒ CARRIAGE RETURN

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PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. F6-107 ~~LED 20~~

PROGRAM PREPARED BY: R.A.L

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 05

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0500	106F0862		·		
		01	220A7F74		·		
		02	2A10040 8		·		
		03	2020 0J46		·	☒	
		04	5J06 104F		·		
		05	2F08062J		·		
		06	0430 0J46		·	..	
		07	7J4F 1F30		·	☒	
		08	5242424F		·		
		09	1F201 8VQ		·		
		10	xB6350		·		
		11	xR1305		·	☒	} DATA OUTPUT #2 (12.1)
		12	xU1300		·		
		13	xZ0304		·		
		14	xR1900		·		} ALPHANUMERIC (19.0)
		15	xU1900		·	☒	
10000004	'	16	2020 1810		·		
		17	4F2F0806		·		"ED50"
		18	2J042018		·		
		19	VQ000000		·	☒ ·	
		20	B0535		·	x26350	
		21	Y0522		·		
		22	B[6 3 5 9 12]		·		
		23	M0647		·	☒ 1@3	
		24	xR2102		·		} ANTILOG PRINTOUT (LEDERLE PROG 21)
		25	xU2100		·		
		26	xZ0002		·		
		27	B0522		·	☒	
		28	S0536		·	xB6352	
		29	T0537		·		
		30	xZ1600		·		BREAKPOINT
		31	B0719		·	☒ "L"@29	

LPR 5124-1

☒ CARRIAGE RETURN

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PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. ~~LED 20~~ F6-107

PROGRAM PREPARED BY: R.A.L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 05

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		05 32	S	0229	·	1@29	
		33	T	0000	·		→ START NEXT ASSAY
		34	x Z	0007	·		STOP
		35	x Z	63500	·	☒	
		36	x B	63522	·		
		37	B	0522	·		
		38	A	0229	·	1@29	
		39	U	0521	·	☒	
		40	x Z	0012	·		
		41	x Z	0100	·		
		42	x Z	0308	·		
		43	x Z	0112	·	☒	
		44	M	0645	·	0.5@0 (1@1)	P, Z SUBROUTINE ↓
		45	x M	63446	·		
		46	x H	63366	·		
		47	S	0652	·	☒ 12.5@8	
		48	T	0550	·		→ t<5
		49	U	0136	·		→ t≥5; SET w=0
		50	x B	63366	·	$t^2/_{2n}$@8	
		51	E	0655	·	☒ 7W WWWQ	FRACTION EXTRACT
		52	D	0649	·	1@7	
		53	x C	63355	·		
		54	x S	63355	·		
		55	x R	2309	·	☒	EXPONENTIAL (17.0)
		56	x U	23022	·		
		57	D	0646	·	1@2	
		58	x C	63344	·		
		59	x B	63366	·	☒	
		60	E	0656	·	WW80 0000	INTEGRAL EXTRACT
		61	M	0651	·	1@21	→ INT($t^2/_L$) @29
		62	A	0644	·	L($\frac{1}{L!}e^{-0}$)	= 20663
		63	Y	0600	·	☒	

LPR 5124-2

ROYAL MCBEE, ATHENS, G. HEGEMAN

☒ CARRIAGE RETURN

· = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. ~~LEO 20~~ EC-107

PROGRAM PREPARED BY: R.A.L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 06

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0600	B	]	·	$\frac{1}{\sqrt{2\pi}} e^{-I}$ @	-1
		01	xM	6334	·		
		02	D	0645	·	1 @ 1	
		03	xC	6344	·	☒ $Z = \frac{1}{\sqrt{2\pi}} e^{-t^2/2}$	@ 0
		04	xB	6346	·	t @ 4	
		05	M	0662	·	q @ -1	
		06	T	0637	·		
		07	A	0647	·	☒ .1 @ 3	
		08	xC	6333	·	$1 + q\|t\|$	@ 3
		09	B	0648	·	1 @ 4	
		10	xD	6333	·		
		11	xC	6332	·	☒ $[1+q\|t\|]^{-1}$	@ 1 = u
		12	B	0661	·	$\sqrt{2}\, a_5$ @ 1	
		13	xM	6332	·	u @ 1	
		14	D	0645	·	1 @ 1	
		15	A	0660	·	☒ $\sqrt{2}\, a_4$ @ 1	
		16	xM	6332	·		
		17	D	0645	·		
		18	A	0659	·	$\sqrt{2}\, a_3$ @ 1	
		19	xM	6332	·	☒	
		20	D	0645	·		
		21	A	0658	·	$\sqrt{2}\, a_2$ @ 1	
		22	xM	6332	·		
		23	D	0645	·	☒	
		24	A	0657	·	$\sqrt{2}\, a_1$ @ 1	
		25	xM	6332	·		
		26	D	0645	·		
		27	xC	6331	·	☒ $\sqrt{2} \sum_1^5 a_i u^i$	@ 1
		28	xB	6346	·		
		29	T	0641	·		
		30	xB	6321	·		
		31	xM	6341	·	☒ Z	@ 0

LPR 5124-1

ROYAL MCBEE, ATHENS, O. H826228

☒ CARRIAGE RETURN

· CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. ~~LED-20~~ FC-107

PROGRAM PREPARED BY: R.A.L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 06

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0632	x	C6345	·		
		33		B0645	·	T@1	
		34	x	S63455	·		
		35	x	C63455	·	☒ P@1	
		36		U[0059]	·		
		37	x	C63333	·		
		38		B0647	·	1@3	
		39	x	S63333	·	☒	
		40		U0608	·		
		41	x	B63311	·		
		42	x	M63444	·		
		43		U06355	·	☒ CONTENTS OF	LOCATION
		44		Z06663	·	$L(\frac{1}{\sqrt{2\pi}}e^{-0})$	
)0000031	'	45	4000000000		·	1@1	
		46	2000000000		·	1@2	
		47	1000000000		·	☒ 1@3	
		48	8000000000		·	1@4	
		49	1000000000		·	1@7	
		50	8000000		·	1@8	
		51	400		·	☒ 1@21	
		52	6400000000		·	12.5@8	
		53	7K70F3K6		·	1.96@1	
		54	WWWW0000		·	b@4 MASK	
		55	7WWWWQ		·	☒ FRACTION	t²/2 MASK
		56	WW8000000		·	INTEGRAL	t²/2 MASK
		57	1470GW3F		·	$\sqrt{2}a_1$ @1	
		58	Q92Q0W1J		·	$\sqrt{2}a_2$ "	
		59	7203GJ0J		·	☒ $\sqrt{2}a_3$ "	
		60	8G708FFJ		·	$\sqrt{2}a_4$ "	
		61	5523375J		·	$\sqrt{2}a_5$ "	
		62	3G4JQ1WJ		·	q @ -1	
		63	662114JJ		·	☒ ——→	$\frac{1}{\sqrt{2\pi}}\exp\{0\}$ @ -1

LPR 5124-2

ROYAL MCBEE, ATHENS, O. H82655E

☒ CARRIAGE RETURN

· = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.	PROGRAM NO. F6-107 ~~LGP-20~~	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE
		R.A.L.	POOL Review	4-20-59

PROBLEM: PROBIT ANALYSIS

TRACK 07

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·				·		
	·	☒			·		
		070 0	2 5 9 2 3 J Q 4		·		Init expL -1]@-1
		0 1	K K 2 5 F 1 8		·		-2 "
		0 2	5 1 5 F W W J		·		-3 "
		0 3	1 K Q K K 2 6		·	☒	-4 "
		0 4	G 0 2 F 0 6		·		-5 "
		0 5	4 0 J Q F 2		·		-6 "
		0 6	1 7 K 7 5 8		·		" -7 "
		0 7	8 J 5 4 F		·	☒	" -8 "
		0 8	3 3 9 W Q		·		" -9 "
		0 9	1 2 W K Q		·		" -10 "
		1 0	6 W J 8		·		" -11 "
		1 1	2 9 1 Q		·	☒	" -12 "
		1 2			·		
		1 3			·		
		1 4	x C 6 3 2 4		·		SET Acc. = 0
		1 5	U 0 0 3 7		·	☒	START NEW ITERATION
• 0 0 0 0 0 0 0 0	'	1 6			·		
		1 7			·		
		1 8			·		
		1 9			·	☒	
		2 0			·		
		2 1			·		
		2 2			·		
		2 3			·	☒	
		2 4			·		
		2 5			·		
		2 6			·		
		2 7			·	☒	
		2 8			·		
		2 9			·		
		3 0			·		
		3 1			·	☒	

LPR 5124-1

ROYAL MCBEE, ATHENS, O. H826228

☒ CARRIAGE RETURN

· = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.

PROGRAM NO. ~~LED 20~~ F6-107

PROGRAM PREPARED BY: R.A.L.

PROGRAM CHECKED BY: POOL Review

DATE 4-20-59

PROBLEM: PROBIT ANALYSIS - STORAGE

TRACK 6300

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	~~CONTENTS OF ADDRESS~~	~~REMARKS~~
						q	QUANTITY STORED
		6300					
		01					
		02					
		03				☒	
		04					
		05					
		06					
		07				☒	
		08					
		09					
		10					
		11				☒	
		12					
		13					
		14					
		15				☒	
		16					
		17					
		18					
		19				☒	
		20				$q_n + 8$	$\bar{x}\ \Sigma n w x$
		21				$q_n + 8$	$\bar{y}\ \Sigma n w y$
		22				$q_n + 4$	$n_i w_i y_i$
		23				☒ $q_n + 4$	$n_i w_i x_i$
		24				$0, q_n$	$P_i Q_i, n_i w_i$
		25					
		26					
		27				☒	
		28					
		29					
		30					
		31				☒ 1	$\sqrt{2}\ \Sigma a_i u^i$

LPR 5124-1

ROYAL MCBEE, ATHENS, G. H0516333

☒ CARRIAGE RETURN

· = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.	PROGRAM NO. F6-107 ~~LEO 20~~	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE
		R.A.L.	POOL Review	4-20-59

PROBLEM: PROBIT ANALYSIS - STORAGE

TRACK 6300

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	~~CONTENTS OF ADDRESS~~	NOTES
	.					q	QUANTITY STORED
	.	☒					
		6 3 1 2			.	1	$[1+q\|t\|]^{-1} = u$
		1 3 1 3			.	3	$1+q\|t\|$
		1 3 1 4			.	2	$\exp\{-\text{FRAC } t^2/2\}$
		1 3 1 5			.	☒ 1	FRACTIONAL $t^2/2$
		1 3 1 6			.	8	$t^2/2$
		1 3 1 7			.	4	$1.96S$
		1 3 1 8			.	$7-(q_n/2)$	$1.96S$
		1 3 1 9			.	☒ $8-q_n$	$(m-\bar{x})^2/[XX]$
		1 4 0			.	4	$m-\bar{x}$
		1 4 1			.	q_n+8	$b[xy]$
		1 4 2			.	8	$b\bar{x}$
		1 4 3			.	☒ 4	b_{j+1}
		1 4 4			.	0	z
		1 4 5			.	1	P
		1 4 6			.	4	t
		1 4 7			.	☒ $12-q_n$	V(m)
		1 4 8			.	29	d.f.
		1 4 9			.	q_n+8	Chi-SQUARE
		1 5 0			.	4	m = LOG ED 50
		1 5 1			.	☒ 4	lower 95% CONF. LIMIT
		1 5 2			.	4	UPPER " " "
		1 5 3			.	4	$\bar{x}$ (TEMP STORE x_i)
		1 5 4			.	4	$\bar{y}$ (" " y_i)
		1 5 5			.	☒ q_n+8	$[XX]$ (" " Σnwx^2)
		1 5 6			.	q_n+8	$[xy]$ (" " $\Sigma nwxy$)
		1 5 7			.	q_n+8	$[yy]$ (" " Σnwy^2)
		1 5 8			.	q_n	Σnw
		1 5 9			.	☒ q_n+4	Σnwx
		1 6 0			.	q_n+4	Σnwy
		1 6 1			.	29	CYCLE COUNTER
		1 6 2			.	4	b (SLOPE)
		1 6 3			.	☒ 8	a (INTERCEPT)

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ROYAL MCBEE, ATHENS, O. H82622X

☒ CARRIAGE RETURN

. = CONDITIONAL STOP CODE