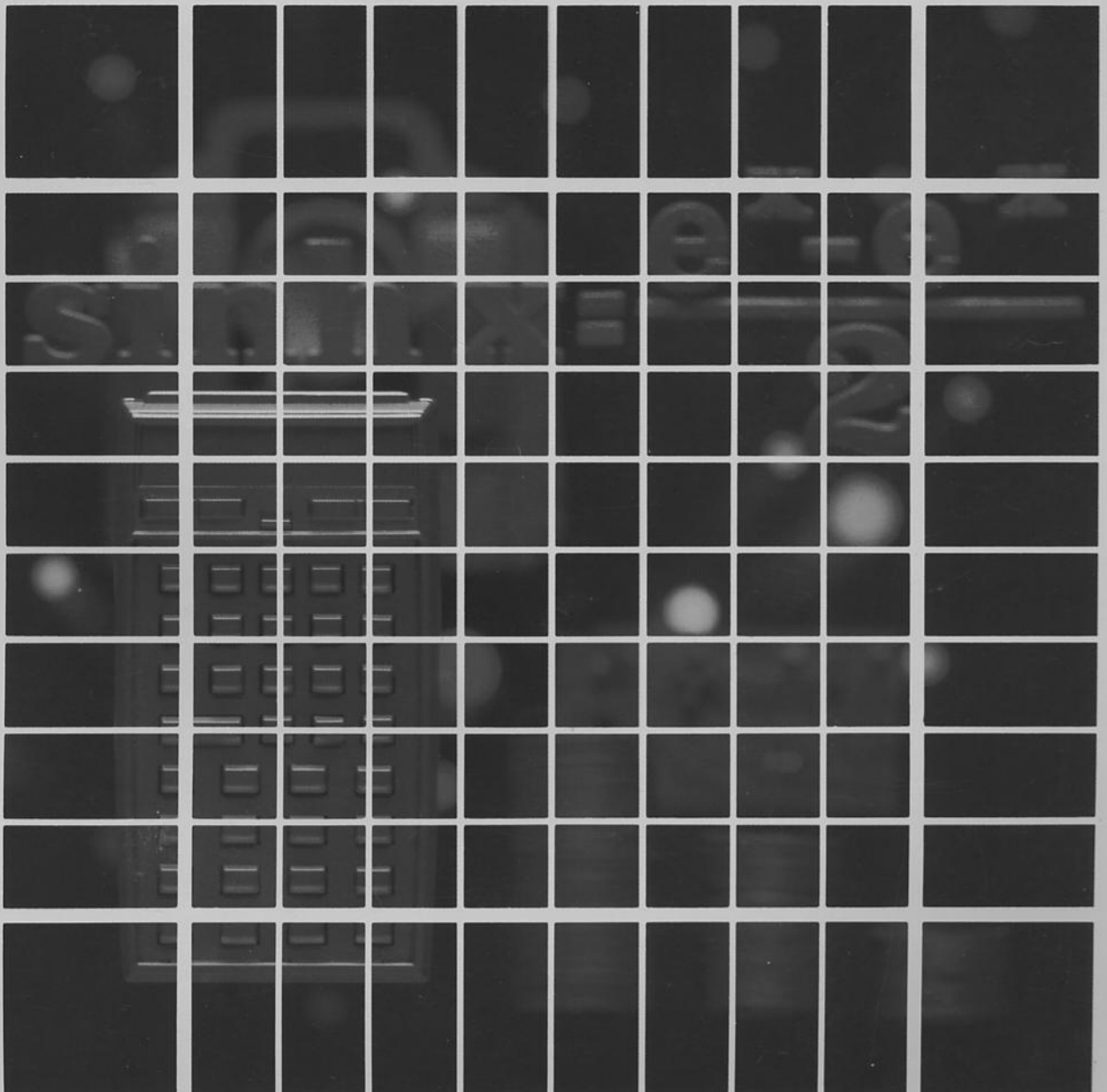


HEWLETT-PACKARD

HP-41C

USER'S
LIBRARY SOLUTIONS

Applied statistics II



PROGRAM LISTING

STAT.10

 PROGRAMMAUFLISTUNG
 LISTAGE DU PROGRAMME
 LISTATO DI PROGRAMMA

01*LBL "ANVA6"	58 X*Y?	115 /	172 RCL 20	229 GTO 10
02*LBL F	59 GTO 01	116 STO 23	173 1	230*LBL 16
03 CF 01	60 ADV	117 RCL 10	174 -	231 XEQ 04
04 CF 02	61*LBL 02	118 RCL 11	175 "D.L."	232 XEQ 06
05 CF 03	62 RCL IND 25	119 -	176 XEQ 11	233 GTO 18
06 CLRG	63 "Σ.A"	120 STO 17	177 STO 00	234*LBL 14
07 STOP	64 XEQ 11	121 RCL 20	178 RCL 13	235 FS? 03
08 STO 20	65 X↑2	122 RCL 21	179 "S.C."	236 GTO 18
09 11	66 RCL 21	123 *	180 XEQ 11	237*LBL 17
10 X<=Y?	67 RCL 22	124 RCL 22	181 X<>Y	238 XEQ 03
11 GTO 13	68 *	125 1	182 /	239 XEQ 06
12 STOP	69 /	126 -	183 "C.M."	240*LBL 18
13 STO 21	70 ST+ 13	127 *	184 STO 20	241 "INT.A*B
14 STOP	71 71S2	128 STO 16	185 XEQ 11	242 AVIEW
15 STO 22	72 RCL 20	129 /	186 FS? 03	243 RCL 18
16 ADV	73 RCL 25	130 STO 15	187 GTO 07	244 "D.L."
17*LBL 01	74 X*Y?	131 RCL 18	188 FS? 02	245 XEQ 11
18 STOP	75 GTO 02	132 STO 00	189 GTO 08	246 RCL 14
19 ST+ 23	76 RCL 14	133 RCL 16	190 XEQ 05	247 "S.C."
20 ΣREG 14	77 X↑2	134 STO 01	191 XEQ 06	248 XEQ 11
21 Σ+	78 RCL 20	135 RCL 23	192 GTO 09	249 RCL 27
22 GTO 01	79 RCL 21	136 RCL 15	193*LBL 08	250 "C.M."
23*LBL B	80 *	137 /	194 XEQ 03	251 XEQ 11
24 RCL 23	81 RCL 22	138 STO 05	195 XEQ 06	252 RCL 15
25 "Σ"	82 *	139 XEQ 10	196 GTO 09	253 /
26 XEQ 11	83 /	140 STO 27	197*LBL 07	254 "F"
27 ADV	84 STO 24	141 .05	198 FS? 02	255 XEQ 11
28 ST+ IND 25	85 RCL 15	142 X>Y?	199 GTO 09	256 RCL 27
29 ST+ 10	86 -	143 SF 03	200 XEQ 04	257 "P"
30 X↑2	87 CHS	144 RCL 23	201 XEQ 06	258 XEQ 11
31 RCL 22	88 STO 10	145 RCL 18	202*LBL 09	259 ADV
32 /	89 RCL 11	146 *	203 "FACT.B"	260 "ERR."
33 ST+ 11	90 RCL 24	147 RCL 15	204 AVIEW	261 AVIEW
34 0	91 -	148 RCL 16	205 RCL 21	262 RCL 16
35 STO 23	92 STO 11	149 *	206 1	263 "D.L."
36 71S2	93 RCL 12	150 +	207 -	264 XEQ 11
37 RCL 20	94 RCL 24	151 RCL 18	208 "D.L."	265 RCL 17
38 RCL 25	95 -	152 RCL 16	209 XEQ 11	266 "S.C."
39 X*Y?	96 STO 12	153 +	210 STO 00	267 XEQ 11
40 GTO 01	97 RCL 13	154 /	211 RCL 12	268 RCL 15
41 RCL 10	98 RCL 24	155 STO 25	212 "S.C."	269 "C.M."
42 "Σ.B"	99 -	156 RCL 16	213 XEQ 11	270 XEQ 11
43 XEQ 11	100 STO 13	157 RCL 18	214 X<>Y	271 ADV
44 ADV	101 RCL 11	158 +	215 /	272 RCL 20
45 X↑2	102 RCL 12	159 STO 26	216 "C.M."	273 RCL 21
46 RCL 20	103 RCL 13	160 "ANVA"	217 STO 28	274 RCL 22
47 RCL 22	104 +	161 AVIEW	218 XEQ 11	275 *
48 *	105 -	162 RTN	219 FS? 01	276 *
49 /	106 STO 14	163*LBL C	220 GTO 15	277 1
50 ST+ 12	107 RCL 20	164 SF 01	221 FS? 02	278 -
51 0	108 1	165 GTO 20	222 GTO 14	279 "TOT."
52 STO 10	109 -	166*LBL A	223 GTO 17	280 AVIEW
53 STO 25	110 RCL 21	167 SF 02	224*LBL 15	281 "D.L."
54 1	111 1	168*LBL 20	225 FS? 03	282 XEQ 11
55 ST+ 26	112 -	169*LBL D	226 GTO 16	283 RCL 10
56 RCL 21	113 *	170 "FACT.A"	227 XEQ 05	284 "S.C."
57 RCL 26	114 STO 18	171 AVIEW	228 XEQ 06	285 XEQ 11

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.10

286 RTN	343 3	400 FSPC 04
287*LBL E	344 1/X	401 XEQ 12
288 STOP	345 Y+X	402 RTN
289 ST- 23	346 *	403*LBL 12
290 E-	347 1	404 1
291 GTO 01	348 RCL 03	405 X<>Y
292*LBL 11	349 -	406 -
293 "F="	350 -	407 RTN
294 ARCL X	351 STO 07	408 .END.
295 AVIEW	352 RCL 02	
296 RTN	353 RCL 05	
297*LBL 03	354 2	
298 RCL 16	355 ENTER↑	
299 STO 01	356 3	
300 RCL 15	357 /	
301 RTN	358 Y+X	
302*LBL 04	359 *	
303 RCL 10	360 RCL 03	
304 STO 01	361 +	
305 RCL 23	362 SQR	
306 RTN	363 RCL 07	
307*LBL 05	364 X<>Y	
308 RCL 26	365 /	
309 STO 01	366 STO 00	
310 RCL 25	367 "X07"	
311 RTN	368 SF 04	
312*LBL 06	369 ABS	
313 RCL 28	370 1	
314 X<>Y	371 RCL 00	
315 /	372 ,196854	
316 STO 05	373 *	
317 "F"	374 +	
318 XEQ 11	375 RCL 00	
319 RCL 01	376 X↑2	
320 XEQ 10	377 ,115194	
321 "P"	378 *	
322 XEQ 11	379 +	
323 FIX 2	380 RCL 00	
324 ADV	381 3	
325 RTN	382 Y+X	
326*LBL 10	383 ,000344	
327 2	384 *	
328 ENTER↑	385 +	
329 9	386 RCL 00	
330 /	387 4	
331 STO 02	388 Y+X	
332 RCL 00	389 ,019527	
333 /	390 *	
334 STO 03	391 +	
335 RCL 02	392 -4	
336 RCL 01	393 Y+X	
337 /	394 2	
338 STO 02	395 /	
339 1	396 CHS	
340 -	397 1	
341 CHS	398 +	
342 RCL 05	399 FIX 3	

STAT.10

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers Datenspeicher Registres de données Registri				Status Betriebsart Modes opératoires Modi operativi			
00	T _a	50		Size	030	Total Reg.	
	.			Eng	☐	Fix	☒
	.			Deg	☐	Rad	☐
	.			Sci	☐	Grad	☐
05	.	55		Purpose Bedeutung Signification Scopo		Flags	
	.					SET	CLEAR
	.			00			
	.			01	Model II	X	
10	T _b	60		02	Model I	X	
	T _g ^{2/n}			03	AxB signif.	X	
	T _b /an			04	P(F)	X	
	T _a ^{2/bn}			05			
				06			
15	Error M.S.	65		07			
	Error d.f.			08			
	Error S.S.			09			
	Interct. d.f.			10			
				11	Audio execute		
20	a	70		12			
	b			13			
	n			14			
	C.F.			15			
	pooled var.			16			
25	pooled d.f.	75		17			
	P interact.			18			
				19			
				20			
				21	Printer Enable		
30		80		22	Number Input		
				23	Alpha Input		
				24	Range Ignore		
				25	Error Ignore		
				26	Audio Enable		
35		85		27	User Mode		
				28	Decimal Point		
				29	Digit Grouping		
				Assignments Tastenbelegung/Assignations/Assegnamenti			
40		90		Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto
45		95					
		99					

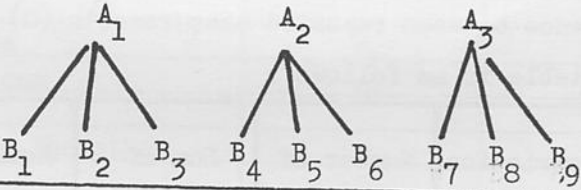
THREE FACTORS ANALYSIS OF VARIANCE

B nested in A, C crossed with A and B

DESCRIPTION

This type of ANOVA is frequently used, when several treatments (a levels of factor A) are studied in subgroups of experimental units (animals, patients), and each individual is tested repeatedly over periods of time. The program can handle up to 12 levels of Factor C (périods); if c is larger than 12, the sign ERROR is displayed.

Factor A :
(a = 3)



Factor B
(b = 3)

Factor C
(c = 4)

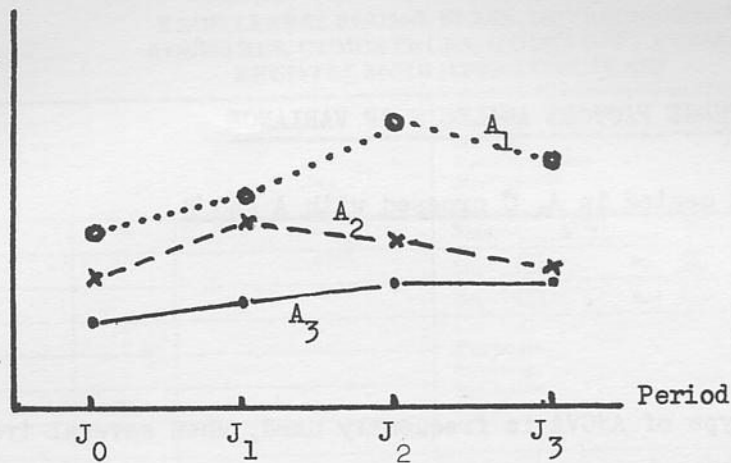
J_0	-	-	-	-	-	-	-	-	-
J_1	-	-	-	-	-	-	-	-	-
J_2	-	-	-	-	-	-	-	-	-
J_3	-	-	-	-	-	-	-	-	-

Each level of Factor A can be considered as a complete randomized block experiment, giving a tables such as :

Factor B (blocks)	Factor C				
	J ₀	J ₁	J ₂	J ₃	
B ₁	-	-	-	-	T _b
B ₂	-	-	-	-	
B ₃	-	-	-	-	

These a tables are entered one after the other and the program computes, for each table, the means of the different periods. The experimental results can be represented graphically, using these means as points of a curves :

STAT.11
Mean
response



There are two error terms in the ANOVA :

- Error I, which is the variation among subgroups within groups (like in a nested ANOVA) is used to test the difference between groups.
- Error II, which is the interaction BxC within groups, is used to test the difference between repeated measurements (C) and the interaction AxC

The ANOVA table is as follows :

Source of variation	Number of d.f.	Sum of squares	Mean square	F
A Between groups	$(a - 1)$		s_A^2	$s_A^2 / s_{B(A)}^2$
B Between subgr. within groups (Error I)	$a(b - 1)$		$s_{B(A)}^2$	
C Between periods	$(c - 1)$		s_C^2	$s_C^2 / s_{BC(A)}^2$
Interaction AxC	$(a-1)(c-1)$		s_{AC}^2	$s_{AC}^2 / s_{BC(A)}^2$
Interaction BxC within groups (Error II)	$a(b-1) \cdot (c-1)$		$s_{BC(A)}^2$	
Total	$(abc - 1)$			

The test of Factor A checks if there is a difference between the treatments as a whole (over all the periods); the test of Factor C, the difference between the periods (over all the levels of A); the test of the interaction AxC is a test of the parallelism of the a curves.

The ANOVA can be completed by comparisons between the points of the curves, using Error II as the Error Mean Square.

STAT.11

EXAMPLE 1 -

A Product	B Patient	C - Period			
		J ₁	J ₂	J ₃	J ₄
A ₁	1	3,37	3,11	3,23	3,12
	3	4,47	3,79	3,94	3,14
	4	4,66	4,40	3,76	4,35
	6	5,13	4,28	3,79	3,53
A ₂	2	7,27	6,86	5,99	5,54
	5	6,60	5,98	6,02	5,47
	7	7,74	6,87	6,60	6,73

$\Sigma T=21,61$
 $MOY=7,20$
 $\Sigma T=19,71$
 $MOY=6,57$
 $\Sigma T=18,61$
 $MOY=6,20$
 $\Sigma T=17,74$
 $MOY=5,91$

XEQ "ANVA7"
 2,00 RUN
 4,00 RUN
 4,00 RUN
 3,37 RUN
 3,11 RUN
 3,23 RUN
 3,12 RUN
 XEQ B
 $\Sigma B=12,83$
 4,47 RUN
 3,79 RUN
 3,94 RUN
 3,14 RUN
 XEQ B
 $\Sigma B=15,34$
 4,66 RUN
 4,40 RUN
 3,76 RUN
 4,35 RUN
 XEQ B
 $\Sigma B=17,17$
 5,13 RUN
 4,28 RUN
 3,79 RUN
 3,53 RUN
 XEQ B
 $\Sigma B=16,73$

$\Sigma T=17,63$
 $MOY=4,41$
 $\Sigma T=15,58$
 $MOY=3,98$
 $\Sigma T=14,72$
 $MOY=3,68$
 $\Sigma T=14,14$
 $MOY=3,54$
 3,00 RUN
 7,27 RUN
 6,86 RUN
 5,99 RUN
 5,54 RUN
 XEQ B
 $\Sigma B=25,66$
 6,60 RUN
 5,98 RUN
 6,02 RUN
 5,47 RUN
 XEQ B
 $\Sigma B=24,07$
 7,74 RUN
 6,87 RUN
 6,60 RUN
 6,73 RUN
 XEQ B
 $\Sigma B=27,94$

ANVA
 A
 $D.L.=1,00$
 $S.C.=46,11$
 $C.M.=46,11$
 $F=48,48$
 $P=0,002$
 ERR.B(A)
 $D.L.=5,00$
 $S.C.=4,76$
 $C.M.=0,95$
 C
 $D.L.=3,00$
 $S.C.=4,37$
 $C.M.=1,46$
 $F=13,31$
 $P=3,214E-4$
 A*C
 $D.L.=3,00$
 $S.C.=0,17$
 $C.M.=0,06$
 $F=0,52$
 $P=0,343$
 ERR.B*C(A)
 $D.L.=15,00$
 $S.C.=1,64$
 $C.M.=0,11$
 TOT
 $D.L.=27,00$
 $S.C.=57,04$

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

01*LBL "ANYA7"	58 ST+ 24	115 CLS	172 ST+ 09	229 ADV
02*LBL A	59 7ISZ	116 XEQ 07	173 STO 02	230 "TOT"
03 CLRG	60 RCL 25	117 1	174 RCL 26	231 AVIEW
04 STOP	61 RCL 21	118 ST+ 32	175 ST+ 08	232 RCL 09
05 STO 20	62 X>Y?	119 RCL 32	176 STO 03	233 "D.L."
06 STOP	63 GTO 02	120 RCL 20	177 XEQ 05	234 XEQ 11
07 STO 21	64 RCL 22	121 X>Y?	178 ADV	235 RCL 08
08 13	65 X+2	122 GTO 08	179 RCL 21	236 "S.C."
09 X<=Y?	66 RCL 21	123 0	180 1	237 XEQ 11
10 GTO 09	67 RCL 30	124 STO 00	181 -	238 RTN
11 XEQ 07	68 *	125 STO 01	182 STO 02	239*LBL 07
12 ADV	69 /	126*LBL 06	183 ST+ 09	240 35.050
13*LBL 08	70 STO 22	127 RCL IND 27	184 RCL 01	241 STO 27
14 STOP	71 ST+ 29	128 ST+ 00	185 RCL 31	242 RTN
15 STO 30	72 RCL 13	129 X+2	186 /	243*LBL 05
16 ST+ 31	73 RCL 22	130 ST+ 01	187 RCL 10	244 RCL 02
17 ADV	74 -	131 ISG 27	188 -	245 "D.L."
18*LBL 01	75 STO 13	132 RCL 27	189 STO 03	246 XEQ 11
19 STOP	76 RCL 23	133 35	190 ST+ 08	247 RCL 03
20 ST+ IND 25	77 RCL 21	134 -	191 RCL 28	248 "S.C."
21 7ISZ	78 /	135 RCL 21	192 RCL 04	249 XEQ 11
22 ΣREG 14	79 RCL 22	136 X>Y?	193 RCL 02	250 X<>Y
23 Σ+	80 -	137 GTO 06	194 *	251 /
24 GTO 01	81 STO 23	138 ADV	195 STO 04	252 "C.M."
25*LBL B	82 ST+ 26	139 RCL 00	196 /	253 XEQ 11
26 RCL 15	83 RCL 24	140 X+2	197 STO 11	254 RTN
27 ST+ 13	84 RCL 30	141 RCL 21	198 "C"	255*LBL 04
28 RCL 14	85 /	142 /	199 AVIEW	256 RCL 11
29 "ΣB"	86 RCL 22	143 RCL 31	200 XEQ 05	257 /
30 XEQ 11	87 -	144 /	201 XEQ 04	258 STO 05
31 ADV	88 STO 24	145 STO 10	202 "A*C"	259 "F"
32 ST+ 22	89 ST+ 33	146 RCL 20	203 AVIEW	260 XEQ 11
33 X+2	90 RCL 13	147 1	204 RCL 20	261 XEQ 10
34 ST+ 23	91 RCL 23	148 -	205 1	262 RTN
35 CLS	92 RCL 24	149 STO 02	206 -	263*LBL 10
36 0	93 +	150 ST+ 09	207 RCL 21	264 2
37 STO 25	94 -	151 RCL 29	208 1	265 ENTER↑
38 1	95 ST+ 28	152 RCL 10	209 -	266 9
39 ST+ 24	96 0	153 -	210 *	267 /
40 RCL 24	97 STO 00	154 STO 03	211 STO 02	268 STO 35
41 RCL 30	98 STO 01	155 ST+ 08	212 ST+ 09	269 RCL 02
42 X>Y?	99 STO 02	156 RCL 26	213 RCL 33	270 /
43 GTO 01	100 STO 03	157 RCL 31	214 RCL 03	271 STO 36
44 0	101 STO 04	158 RCL 20	215 -	272 RCL 35
45 STO 24	102 STO 05	159 -	216 STO 03	273 RCL 04
46*LBL 02	103 STO 06	160 STO 04	217 ST+ 08	274 /
47 RCL IND 25	104 STO 07	161 /	218 XEQ 05	275 STO 35
48 "ΣT"	105 STO 08	162 STO 11	219 XEQ 04	276 1
49 XEQ 11	106 STO 09	163 "ANYA"	220 "ERR.B*C(A)"	277 -
50 RCL 30	107 STO 10	164 AVIEW	221 AVIEW	278 CHS
51 /	108 STO 11	165 "A"	222 RCL 04	279 RCL 05
52 "MOY"	109 STO 12	166 AVIEW	223 ST+ 09	280 3
53 XEQ 11	110 STO 13	167 XEQ 05	224 STO 02	281 1/X
54 RCL IND 25	111 STO 22	168 XEQ 04	225 RCL 28	282 Y+X
55 ST+ IND 27	112 STO 23	169 "ERR.B(A)"	226 ST+ 08	283 *
56 ISG 27	113 STO 24	170 AVIEW	227 STO 03	284 1
57 X+2	114 STO 25	171 RCL 04	228 XEQ 05	285 RCL 36

STAT.11

PROGRAM LISTING

 PROGRAMMAUFLISTUNG
 LISTAGE DU PROGRAMME
 LISTATO DI PROGRAMMA

286 -	343 RTN
287 -	344*LBL 12
288 STO 37	345 1
289 RCL 35	346 X<>Y
290 RCL 05	347 -
291 2	348 RTN
292 ENTER↑	349*LBL 11
293 3	350 "+="
294 /	351 ARCL X
295 Y↑X	352 AVIEW
296 *	353 RTN
297 RCL 36	354*LBL E
298 +	355 RCL 25
299 SQRT	356 1
300 RCL 37	357 -
301 X<>Y	358 STO 25
302 /	359 STOP
303 STO 38	360 ST- IND 25
304 X>0?	361 E-
305 SF 02	362 GTO 01
306 ABS	363 .END.
307 1	
308 RCL 38	
309 ,196854	
310 *	
311 +	
312 RCL 38	
313 X↑2	
314 ,115194	
315 *	
316 +	
317 RCL 38	
318 3	
319 Y↑X	
320 ,000344	
321 *	
322 +	
323 RCL 38	
324 4	
325 Y↑X	
326 ,019527	
327 *	
328 +	
329 -4	
330 Y↑X	
331 2	
332 /	
333 CHS	
334 1	
335 +	
336 FIX 3	
337 FS?C 02	
338 XEQ 12	
339 "P"	
340 XEQ 11	
341 FIX 2	
342 ADV	

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers Datenspeicher Registres de données Registri				Status Betriebsart Modes opératoires Modi operativi			
00	T_c	50		Size <u>050</u>	Total Reg. _____	User Mode	
	.			Eng ☐	Fix ☒	Sci ☐	On ☒
	.			Deg ☐	Rad ☐	Grad ☐	Off ☐
	.			Purpose Bedeutung Signification Scopo			
05		55		Flags			
						SET	CLEAR
				00			
				01			
				02	P(F) routine	☒	
10	.	60		03			
	.			04			
	Σy^2			05			
				06			
15		65		07			
				08			
				09			
				10			
				11	Audio execute		
20	a	70		12			
	c			13			
	Σy			14			
	ΣT_b^2			15			
	ΣT_c^2			16			
25		75		17			
	Blocks S.S.			18			
				19			
	S.S. BC(A)			20			
	S.S. A			21	Printer Enable		
30	b	80		22	Number Input		
	Σb			23	Alpha Input		
				24	Range Ignore		
				25	Error Ignore		
				26	Audio Enable		
35	T_c	85		27	User Mode		
	mean			28	Decimal Point		
	.			29	Digit Grouping		
	.			Assignments Tastenbelegung/Assignations/Assegnamenti			
	.			Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto
40		90					
45		95					
		99					

David M. BURCH

Astage

Rectory Lane

G&B-WINDLESHAM

GU 20 6BW

H.P.C.C. LIBRARY

NOTICE

The program material contained herein is supplied without representation or warranty of any kind. Hewlett-Packard Company therefore assumes no responsibility and shall have no liability, consequential or otherwise, of any kind arising from the use of this program material or any part thereof.

FACTORIAL EXPERIMENTSDESCRIPTION

A factorial experiment is a design in which several factors are varied together at a few levels, to study the influence of each factor and to be able to detect interactions between them. The size of these experiments increases rapidly with the number of factors. Consequently, in preliminary investigations, it is usual to study each factor at only two levels, the control level and an experimental level supposed to be beneficial. The total number of treatments is :

$$2^3 = 8 \text{ for 3 factors}$$

$$2^4 = 16 \text{ for 4 factors}$$

$$2^5 = 32 \text{ for 5 factors}$$

and each treatment should be replicated n times to have an estimation of the experimental error. Conventionally, each factor is named by a capital letter : A, B, ... with two levels 0 and 1. Each treatment is named by a group of small letters : when a factor is at level 1, the corresponding small letter is used and when it is at level 0, the letter is omitted. For instance,

$$A_0 B_1 C_1 D_0 = bc \quad A_1 B_1 C_1 D_1 = abcd \quad A_0 B_0 C_0 D_0 = (1)$$

To compute the total and mean effect of each factor or interaction, and the corresponding sums of squares, the treatments are classified in a systematic order :

(1) a b ab ; c ac bc abc ; d ad bd abd cd acd bcd abcd ;
e ae be abe ce ace bce abce de ade bde abde cde acde bcde abcde

(after combining A and B, the following letters are added and the corresponding treatments obtained by the product of the previous group and the new letter)

The program can analyze a factorial experiment up to 5 factors; the results are entered in the systematic order, and the mean and S.S. compu-

ted by the method of Yates. In the ANOVA, each factor and interaction have one degree of freedom. When each treatment has been replicated, the estimation of the error variance obtained from the replicates is used to test the several factors and the two-factor interactions. With more than three factors, it is customary not to replicate each treatment and to use, as error variance, the pooled mean squares of the interactions of more than two factors; for instance, in a 2^4 experiment, $ABC + ABD + ACD + BCD + ABCD$ with 5 d.f.

The ANOVA displays : the mean effect of each factor and two-factor interaction, the mean square and the value of F. It has been impossible to include the subroutine for $P(F)$ by lack of space.

USER INSTRUCTIONS I

STAT.12

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.12, tracks 1 to 7			
2	Initialize		XEQ "ANVAS"	
3	Enter : number of factors	f	R/S	
	number of replicates	n	R/S	
	$n = 1$			
4	Input the data in systematic order	y ...	R/S	
	$n > 1$			
4'	Input the replicates of the first treatment (1)	$y_{i...}$	R/S	
	then call		B	
4"	Repeat step 4' for the other treat- ments in systematic order			
5	After the last treatment, Display of the ANOVA :			
	Mean			MOY
	Mean square			C.M.
	F			F
	of each factor and two-factor inter- action; then Error :			
	number of d.f.			D.L.
	mean square			C.M.
6	For another set of data, call and return to step 3		A	

EXAMPLE 1 - Four factors: $n = 1$ (*)

XEQ "ANVA8"		ANVA
4.0000	RUN	A
1.0000	RUN	MOY=0.6125
		CM=1.5006
.6000	RUN	F=10.9037
1.0000	RUN	B
.3000	RUN	MOY=0.4875
1.7000	RUN	CM=0.9506
2.0000	RUN	F=6.9074
1.5000	RUN	C
1.7000	RUN	MOY=1.2375
2.4000	RUN	CM=6.1256
-.4000	RUN	F=44.5095
1.1000	RUN	D
.7000	RUN	MOY=0.0125
1.3000	RUN	CM=0.0006
1.6000	RUN	F=0.0045
1.9000	RUN	AB
2.3000	RUN	MOY=0.1875
2.8000	RUN	CM=0.1406
		F=1.0218
		AC
		MOY=-0.3625
		CM=0.5256
		F=3.8193
		BC
		MOY=0.0625
		CM=0.0156
		F=0.1135
		AD
		MOY=0.1125
		CM=0.0506
		F=0.3678
		BD
		MOY=0.2375
		CM=0.2256
		F=1.6394
		CD
		MOY=0.2375
		CM=0.2256
		F=1.6394
		ERR
		D.L.=5.0000
		C.M.=0.1376

EXAMPLE 2 - Three factors; n = 2 (三)

XEQ "ANVA8"	ANVA
3.0000 RUN	A
2.0000 RUN	MOY=0.6125
	CM=1.5006
.6000 RUN	F=11.0645
-.4000 RUN	B
XEQ B	MOY=0.4875
1.0000 RUN	CM=0.9506
1.1000 RUN	F=7.0092
XEQ B	C
.3000 RUN	MOY=1.2375
.7000 RUN	CM=6.1256
XEQ B	F=45.1659
1.7000 RUN	AB
1.3000 RUN	MOY=0.1875
XEQ B	CM=0.1406
2.0000 RUN	F=1.0369
1.6000 RUN	AC
XEQ B	MOY=-0.3625
1.5000 RUN	CM=0.5256
1.9000 RUN	F=3.8756
XEQ B	BC
1.7000 RUN	MOY=0.0625
2.3000 RUN	CM=0.0156
XEQ B	F=0.1152
2.4000 RUN	ERR
2.8000 RUN	D.L.=8.0000
XEQ B	C.M.=0.1356

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

01*LBL "ANVA8"	58 GTO 21	115 CF 00	172 RCL 73	229 RCL 54
02*LBL A	59 XEQ 08	116 RTN	173 XEQ 15	230 X=0?
03 CLRG	60 SF 02	117*LBL 09	174 RCL 72	231 GTO 24
04 CF 00	61 GTO 20	118 XEQ 02	175 XEQ 15	232 "D"
05 CF 01	62*LBL 02	119 XEQ 05	176 RCL 71	233 AVIEW
06 CF 02	63 10	120 XEQ 07	177 XEQ 15	234 XEQ 19
07 2	64 RCL 00	121 XEQ 05	178 RCL 69	235 RCL 54
08 ENTER↑	65 +	122 SF 00	179 XEQ 15	236 XEQ 23
09 STOP	66 1000	123 XEQ 07	180 RCL 68	237 RCL 62
10 STO 08	67 /	124 CF 00	181 XEQ 15	238 X=0?
11 Y↑X	68 11	125 RTN	182 RCL 67	239 GTO 24
12 STO 00	69 +	126*LBL 21	183 XEQ 15	240 "E"
13 STOP	70 FS? 02	127 XEQ 02	184 RCL 65	241 AVIEW
14 STO 01	71 GTO 10	128 XEQ 05	185 XEQ 15	242 XEQ 19
15 ADV	72 STO 05	129*LBL 25	186 RCL 61	243 RCL 62
16 1	73 GTO 11	130 RCL IND 05	187 XEQ 15	244 XEQ 23
17 X=Y?	74*LBL 10	131 STO IND 06	188 RCL 60	245*LBL 24
18 SF 01	75 STO 06	132 ISG 05	189 XEQ 15	246 "AB"
19 XEQ 02	76*LBL 11	133 1	190 RCL 59	247 AVIEW
20*LBL 01	77 RTN	134 ISG 06	191 XEQ 15	248 RCL 49
21 0	78*LBL 05	135 GTO 25	192 RCL 57	249 XEQ 19
22 STO 02	79 45	136*LBL 20	193 XEQ 15	250 RCL 49
23 FS? 01	80 RCL 00	137 RCL 00	194 RCL 53	251 XEQ 23
24 GTO 04	81 +	138 RCL 01	195 XEQ 15	252 "AC"
25*LBL 03	82 1000	139 *	196 3	253 AVIEW
26 STOP	83 /	140 2	197 RCL 08	254 RCL 51
27 ST+ 02	84 46	141 /	198 X=Y?	255 XEQ 19
28 X↑2	85 +	142 STO 04	199 XEQ 16	256 RCL 51
29 ST+ 03	86 FS? 02	143 RCL 00	200 4	257 XEQ 23
30 GTO 03	87 GTO 12	144 RCL 01	201 RCL 08	258 "BC"
31*LBL B	88 STO 06	145 *	202 X=Y?	259 AVIEW
32 RCL 02	89 GTO 13	146 STO 07	203 XEQ 17	260 RCL 52
33 X↑2	90*LBL 12	147 FS? 01	204 5	261 XEQ 19
34 ST+ 09	91 STO 05	148 GTO 22	205 RCL 08	262 RCL 52
35*LBL 04	92*LBL 13	149 RCL 03	206 X=Y?	263 XEQ 23
36 RCL 02	93 RTN	150 RCL 09	207 XEQ 18	264 RCL 55
37 FS? 01	94*LBL 07	151 RCL 01	208*LBL 14	265 X=0?
38 STOP	95*LBL 06	152 /	209 "ANVA"	266 GTO 26
39 STO IND 05	96 RCL IND 05	153 -	210 AVIEW	267 "AD"
40 ISG 05	97 FS? 00	154 RCL 00	211 "A"	268 AVIEW
41 GTO 01	98 CHS	155 RCL 01	212 AVIEW	269 XEQ 19
42 ADV	99 ISG 05	156 1	213 RCL 47	270 RCL 55
43 XEQ 08	100 RCL IND 05	157 -	214 XEQ 19	271 XEQ 23
44 SF 02	101 +	158 *	215 RCL 47	272 "BD"
45 XEQ 09	102 STO IND 06	159 STO 13	216 XEQ 23	273 AVIEW
46 CF 02	103 ISG 06	160 /	217 "B"	274 RCL 56
47 XEQ 08	104 1	161 STO 03	218 AVIEW	275 XEQ 19
48 SF 02	105 ISG 05	162 GTO 14	219 RCL 48	276 RCL 56
49 3	106 GTO 06	163*LBL 22	220 XEQ 19	277 XEQ 23
50 RCL 08	107 RTN	164 RCL 77	221 RCL 48	278 "CD"
51 X=Y?	108*LBL 08	165 XEQ 15	222 XEQ 23	279 AVIEW
52 GTO 20	109 XEQ 02	166 RCL 76	223 "C"	280 RCL 58
53 XEQ 09	110 XEQ 05	167 XEQ 15	224 AVIEW	281 XEQ 19
54 CF 02	111 XEQ 07	168 RCL 75	225 RCL 50	282 RCL 58
55 4	112 XEQ 02	169 XEQ 15	226 XEQ 19	283 XEQ 23
56 RCL 08	113 SF 00	170 RCL 74	227 RCL 50	284 RCL 63
57 X=Y?	114 XEQ 07	171 XEQ 15	228 XEQ 23	285 X=0?

PROGRAM LISTING

STAT.12

 PROGRAMMAUFLISTUNG
 LISTAGE DU PROGRAMME
 LISTATO DI PROGRAMMA

286 GTO 26	343 /
287 "AE"	344 STO 03
288 AVIEW	345 RTN
289 XEQ 19	346+LBL 19
290 RCL 63	347 RCL 04
291 XEQ 23	348 /
292 "BE"	349 "MOY"
293 AVIEW	350 XEQ 11
294 RCL 64	351 RTN
295 XEQ 19	352+LBL 23
296 RCL 64	353 X12
297 XEQ 23	354 RCL 07
298 "CE"	355 /
299 AVIEW	356 "CM"
300 RCL 66	357 XEQ 11
301 XEQ 19	358 RCL 03
302 RCL 66	359 /
303 XEQ 23	360 "F"
304 "DE"	361 XEQ 11
305 AVIEW	362 RTN
306 RCL 70	363+LBL 11
307 XEQ 19	364 "I="
308 RCL 70	365 ARCL X
309 XEQ 23	366 AVIEW
310+LBL 26	367 RTN
311 "ERR"	
312 AVIEW	
313 "D.L."	
314 RCL 13	
315 XEQ 11	
316 "C.M."	
317 RCL 03	
318 XEQ 11	
319 RTN	
320+LBL 15	
321 X12	
322 RCL 07	
323 /	
324 ST+ 10	
325 RTN	
326+LBL 16	
327 1	
328 STO 13	
329 RCL 10	
330 STO 03	
331 RTN	
332+LBL 17	
333 RCL 10	
334 5	
335 STO 13	
336 /	
337 STO 03	
338 RTN	
339+LBL 18	
340 RCL 10	
341 16	
342 STO 13	

Registers
Datenspeicher
Registres de données
Registri

Status
Betriebsart
Modes opératoires
Modi operativi

00	2^k	50		Size 080	Total Reg. 179	User Mode
	n			Eng ☐	Fix ☒	Sci ☐
	$\sum y$			Deg ☐	Rad ☐	Grad ☐
	$\sum y^2$			Purpose		
	div. T			Bedeutung		
05		55		Signification		
				Scopo		
	div. T ²			Flags		
	$\sum T_g^2$			00	Service	SET CLEAR
				01	"	X
10		60		02	"	X
	Data to			03		X
	42			04		
				05		
				06		
15		65		07		
				08		
				09		
				10		
				11	Audio execute	
20		70		12		
				13		
				14		
				15		
				16		
25		75		17		
				18		
				19		
				20		
				21	Printer Enable	
30		80		22	Number Input	
				23	Alpha Input	
				24	Range Ignore	
				25	Error Ignore	
				26	Audio Enable	
35		85		27	User Mode	
				28	Decimal Point	
				29	Digit Grouping	
				Assignments		
				Tastenbelegung/Assignations/Assegnamenti		
40		90		Function	Key	Function
				Funktion	Taste	Funktion
				Fonction	Touche	Fonction
				Funzione	Tasto	Funzione
45	Data to	95				
	77					
		99				

PRODUCT-MOMENT CORRELATION COEFFICIENT

When studying correlation, we are concerned whether two variables y_1 and y_2 are interdependent and covary. If these variables are normally distributed, the most common measure of this covariation is the product-moment correlation coefficient due to Karl Pearson. If, on a sample of size n , we measure, on each unit, two variables y_1 and y_2 , we get n pairs of values, which can be represented on a graph with axes y_1 and y_2 . If the scattergram is more or less elliptical upward or downward, we can conclude to a positive or negative correlation.

The correlation coefficient computed from the data is :

$$r_{12} = s_{12} / s_1 \cdot s_2$$

s_1 and s_2 being the standard deviations of y_1 and y_2 and s_{12} the covariance :

$$\text{covar} = s_{12} = (\sum y_1 y_2 - \sum y_1 \sum y_2 / n) / (n - 1)$$

If the sample is large, the correlation coefficient can be computed from a two-way frequency table; each class midpoint can be coded as y'_1 and y'_2 and the frequency in each cell is f_i . The standard deviation and covariance are computed as :

$$s_1 = \sqrt{\frac{\sum f y_1'^2 - (\sum f y_1')^2 / \sum f}{\sum f - 1}}$$

$$s_{12} = \frac{\sum f y_1' y_2' - \sum f y_1' \sum f y_2' / \sum f}{\sum f - 1}$$

This coefficient, r , computed from the sample, is an estimation of the parametric coefficient ρ . If $\rho = 0$, there is no correlation between the variables; if $\rho = 1$, there is a perfect positive correlation; if $\rho = -1$, the correlation is negative.

We can test if this correlation coefficient r could be found in a sample coming from a population with a parametric coefficient of zero.

$H_0 : \rho = 0$. If this is the case, the standard error of the coefficient is :

$$s_r = \sqrt{(1 - r^2) / (n - 2)}$$

and the hypothesis can be tested as a t -test with $(n - 2)$ degrees of freedom.

STAT.13

$$t = \frac{r - 0}{\sqrt{(1 - r^2)/(n - 2)}} = r \sqrt{(n - 2)/(1 - r^2)}$$

If the probability $P(t)$ is lower than α , we conclude that $\rho \neq 0$

When the sample size is larger than 25, r can be transformed to a function z (Fisher transformation)

$$z = \frac{1}{2} \ln \left(\frac{1 + r}{1 - r} \right)$$

approximately normally distributed with variance $\sigma^2 = \frac{1}{(n - 3)}$

With this transformation, it is possible to test if a calculated $\underline{r}$ is equal to a parametric value different from zero: $H_0 : \rho = \rho_1$

The value

$$u = \frac{z_1 - z_2}{1/\sqrt{n - 3}}$$

is a normal deviate; z_1 and z_2 being the z transformation of r and ρ_1

With the same transformation, it is possible to test if two calculated correlation coefficients r_1 and r_2 differ significantly.

$$H_0 : \rho_1 = \rho_2 \text{ versus } H_1 : \rho_1 \neq \rho_2$$

$$u = \frac{z_1 - z_2}{\sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}}}$$

If the probability $P(u)$ is lower than α , H_0 can be rejected.

INTRODUCTION

This HP-41C Solutions book was written to help you get the most from your calculator. The programs were chosen to provide useful calculations for many of the common problems encountered.

They will provide you with immediate capabilities in your everyday calculations and you will find them useful as guides to programming techniques for writing your own customized software. The comments on each program listing describe the approach used to reach the solution and help you follow the programmer's logic as you become and expert on your HP calculator.

KEYING A PROGRAM INTO THE HP-41C

There are several things that you should keep in mind while you are keying in programs from the program listings provided in this book. The output from the HP 82143A printer provides a convenient way of listing and an easily understood method of keying in programs without showing every keystroke. This type of output is what appears in this handbook. Once you understand the procedure for keying programs in from the printed listings, you will find this method simple and fast. Here is the procedure:

1. At the end of each program listing is a listing of status information required to properly execute that program. Included is the SIZE allocation required. Before you begin keying in the program, press **[XEQ]** **[ALPHA]** **SIZE** **[ALPHA]** and specify the allocation (three digits; e.g., 10 should be specified as 010).

Also included in the status information is the display format and status of flags important to the program. To ensure proper execution, check to see that the display status of the HP-41C is set as specified and check to see that all applicable flags are set or clear as specified.

2. Set the HP-41C to PRGM mode (press the **[PRGM]** key) and press **[GTO]** **[.]** **[.]** to prepare the calculator for the new program.

3. Begin keying in the program. Following is a list of hints that will help you when you key in your programs from the program listings in this handbook.

- a. When you see " (quote marks) around a character or group of characters in the program listing, those characters are ALPHA. To key them in, simply press **[ALPHA]**, key in the characters, then press **[ALPHA]** again. So "SAMPLE" would be keyed in as **[ALPHA]** "SAMPLE" **[ALPHA]**.
- b. The diamond in front of each LBL instruction is only a visual aid to help you locate labels in the program listings. When you key in a program, ignore the diamond.
- c. The printer indication of divide sign is /. When you see / in the program listing, press **[÷]**.
- d. The printer indication of the multiply sign is ×. When you see × in the program listing, press **[×]**.
- e. The † character in the program listing is an indication of the **[APPEND]** function. When you see †, press **[APPEND]** in ALPHA mode (press **[ALPHA]** and the K key).
- f. All operations requiring register addresses accept those addresses in these forms:

nn (a two-digit number)

IND nn (INDIRECT: **[.]**, followed by a two-digit number)

X, Y, Z, T, or L (a STACK address: **[.]** followed by X, Y, Z, T, or L)

IND X, Y, Z, T or L (INDIRECT stack: **[.]** **[.]** followed by X, Y, Z, T, or L)

Indirect addresses are specified by pressing **[.]** and then the indirect address. Stack addresses are specified by pressing **[.]** **[.]** followed by X, Y, Z, T, or L. Indirect stack addresses are specified by pressing **[.]** **[.]** and X, Y, Z, T, or L.

Printer Listing

```

01 *LBL "SAM
PLE"
02 "THIS IS
A "
03 †SAMPLE
..
04 AVIEW
05 6
06 ENTER↑
07 -2
08 /
09 ABS
10 STO IND
L
11 "R3="
12 ARCL 03
13 AVIEW
14 RTN

```

Keystrokes

```

[ ] [LBL] [ALPHA] SAMPLE [ALPHA]
[ALPHA] THIS IS A [ALPHA]
[ALPHA] [APPEND] SAMPLE
[ ] AVIEW [ALPHA]
6
[ENTER]
2 [CHS]
[+]
[XEQ] [ALPHA] ABS [ALPHA]
[STO] [.] L
[ALPHA] R3= [ ] [ARCL] 03
[ ] AVIEW
[ALPHA]
[ ] [RTN]

```

Display

```

01 LBLT SAMPLE
02T THIS IS A
03T †SAMPLE
04 AVIEW
05 6
06 ENTER /
07 -2
08 /
09 ABS
10 STO IND L
11T R3=
12 ARCL 03
13 AVIEW
14 RTN

```

STAT.13

USER INSTRUCTIONS

PROGRAMMABLAUF
INSTRUCTIONS D'EMPLOI
NORME OPERATIVE

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.13, tracks 1 to 6			
2	Initialize		XEQ "CORR"	
	a - <u>Ungrouped data</u>			
3	Call		A	
4	Input the pairs of data	y_{i1} y_{i2}	R/S R/S	
5	<u>Correction routine</u> Input the complete pair and call input the erroneous pair	y_{1E} y_{2E}	E R/S R/S	
	then the correct one			
6	After the last pair, call Display of : means		B	MOY.1 MOY.2
	standard deviations			D.S.1 D.S.2
	covariance			COV.1.2
	correlation coefficient			r 1.2
	b - <u>Grouped data</u>			
7	Call		C	
8	Input y'_1 , class midpoint of the first column	y'_1	R/S	
9	Input : y'_2 , class midpoint of the first row	y'_2	R/S	
	f, frequency of the corres- ponding cell	f	R/S	
10	Repeat step 9 for the other rows			
11	After the last row, call		B	
12	Repeat steps 8 to 11 for the other columns			
13	<u>Correction routine</u> Complete the entry of the erroneous group and call		E	
	Input again :	y'_{1E} y'_{2E} f_E	R/S R/S R/S	
	then the correct group :	y'_{1C} y'_{2C} f_C	R/S R/S R/S	
14	After the last column, call Display of : sample size correlation coeff.		D	Σf r 1.2

STAT.13

EXAMPLE 2 - (continued)

4.00 RUN
2.00 RUN

5.00 RUN
3.00 RUN

XEQ B
2.00 RUN
-1.00 RUN
1.00 RUN

0.00 RUN
1.00 RUN

1.00 RUN
1.00 RUN

2.00 RUN
2.00 RUN

3.00 RUN
4.00 RUN

4.00 RUN
2.00 RUN

5.00 RUN
2.00 RUN

XEQ B
1.00 RUN
-2.00 RUN
1.00 RUN

-1.00 RUN
2.00 RUN

0.00 RUN
3.00 RUN

1.00 RUN
2.00 RUN

2.00 RUN
5.00 RUN

3.00 RUN
3.00 RUN

4.00 RUN
1.00 RUN

XEQ B
0.00 RUN
-3.00 RUN
1.00 RUN

-2.00 RUN
2.00 RUN

-1.00 RUN
2.00 RUN

XEQ B
-5.00 RUN
1.00 RUN

-4.00 RUN
1.00 RUN

-3.00 RUN
2.00 RUN

-2.00 RUN
1.00 RUN

XEQ B
-5.00 RUN
-6.00 RUN
1.00 RUN

-5.00 RUN
2.00 RUN

XEQ B

$\Sigma f = 100.00$
 $r.1.2 = 0.78$

$p = 0 ?$

$t = 12.43$
 $P = 9.000E-10$

$p = p_1 ?$

$u = 3.53$
 $P = 0.001$

$r_1 = r_2 ?$

$u = -1.18$
 $P = 0.239$

XEQ D

XEQ F

XEQ G
0.60 RUN

XEQ H
0.6213 RUN
0.8017 RUN
36.00 RUN
17.00 RUN

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.13

01*LBL "CORR"	58*LBL 02	115 RCL 04	172 1	229 GTO 06
02*LBL A	59 STOP	116 *	173 -	230 RTN
03 CF 00	60 STO 20	117 SQRT	174 STO 25	231*LBL 09
04 CLRG	61*LBL 07	118 /	175 1	232 RCL 07
05*LBL 01	62 STOP	119 STO 00	176 STO 06	233 GTO 06
06 STOP	63 STO 21	120 "R.1.2"	177*LBL 03	234*LBL 08
07 STOP	64 STOP	121 XEQ 11	178 RCL 03	235 RCL 04
08 X<>Y	65 STO 22	122 ADV	179 *	236 GTO 06
09 ΣREG 14	66 ST+ 19	123 CF 00	180 RCL 05	237 RTN
10 Σ+	67 RCL 20	124 CF 13	181 1	238*LBL 06
11 ADV	68 *	125 RTN	182 +	239 1
12 GTO 01	69 *	126*LBL F	183 *	240 X<>Y
13*LBL B	70 ST+ 02	127 RCL 00	184 LASTX	241 -
14 MEAN	71 RCL 21	128 RCL 19	185 1	242 FS?C 02
15 "MOY.1"	72 RCL 22	129 2	186 +	243 XEQ 05
16 XEQ 11	73 *	130 -	187 STO 05	244 FIX 3
17 STO 20	74 ST+ 03	131 STO 01	188 /	245 "P"
18 X<>Y	75 RCL 21	132 1	189 ST+ 06	246 XEQ 11
19 "MOY.2"	76 *	133 RCL 00	190 ZDSZ	247 FIX 2
20 XEQ 11	77 ST+ 04	134 X↑2	191 GTO 03	248 RTN
21 ADV	78 RCL 22	135 -	192 RCL 06	249*LBL 05
22 SDEV	79 RCL 20	136 /	193 RCL 04	250 2
23 "D.S.1"	80 *	137 SQRT	194 *	251 /
24 XEQ 11	81 ST+ 05	138 *	195 FS? 01	252 RTN
25 STO 22	82 RCL 20	139 SF 13	196 GTO 15	253*LBL 12
26 X<>Y	83 *	140 "T"	197 GTO 06	254 RCL 02
27 "D.S.2"	84 ST+ 06	141 XEQ 11	198*LBL 15	255 SIN
28 XEQ 11	85 ADV	142 CF 13	199 RTN	256 GTO 13
29 STO 23	86 GTO 07	143 ABS	200*LBL 04	257 RTN
30 RCL 18	87*LBL B	144 RCL 01	201 RCL 02	258*LBL 11
31 RCL 14	88 GTO 02	145 RAD	202 2	259 "t="
32 RCL 16	89*LBL D	146 SQRT	203 *	260 ARCL X
33 *	90 RCL 06	147 /	204 PI	261 AVIEW
34 RCL 19	91 RCL 05	148 ATAN	205 /	262 RTN
35 /	92 X↑2	149 STO 02	206 STO 07	263*LBL E
36 -	93 RCL 19	150 RCL 01	207 3	264 FS? 00
37 RCL 19	94 /	151 2	208 RCL 01	265 GTO 10
38 1	95 -	152 /	209 X=Y?	266 STOP
39 -	96 STO 06	153 INT	210 GTO 12	267 STOP
40 /	97 RCL 04	154 LASTX	211 1	268 X<>Y
41 "COV.1.2"	98 RCL 03	155 X*Y?	212 STO 05	269 Σ-
42 XEQ 11	99 X↑2	156 GTO 04	213 ST- 01	270 GTO 01
43 ADV	100 RCL 19	157 0	214 X=Y?	271*LBL 10
44 RCL 22	101 /	158 STO 05	215 GTO 09	272 STOP
45 RCL 23	102 -	159*LBL 16	216 SF 01	273 STO 20
46 *	103 STO 04	160 RCL 02	217 XEQ 16	274 STOP
47 /	104 RCL 02	161 COS	218 CF 01	275 STO 21
48 STO 00	105 RCL 03	162 X↑2	219*LBL 13	276 STOP
49 SF 13	106 RCL 05	163 STO 03	220 RCL 02	277 STO 22
50 "R.1.2"	107 *	164 RCL 02	221 COS	278 ST- 19
51 XEQ 11	108 RCL 19	165 SIN	222 *	279 *
52 CF 13	109 SF 13	166 STO 04	223 2	280 *
53 ADV	110 "ΣF"	167 RCL 01	224 *	281 ST- 02
54 RTN	111 XEQ 11	168 2	225 PI	282 RCL 21
55*LBL C	112 /	169 X=Y?	226 /	283 RCL 22
56 CLRG	113 -	170 GTO 08	227 RCL 07	284 *
57 SF 00	114 RCL 06	171 /	228 +	285 ST- 03

PROGRAM LISTING

STAT.13

 PROGRAMMAUFLISTUNG
 LISTAGE DU PROGRAMME
 LISTATO DI PROGRAMMA

286 RCL 21	343 STOP
287 *	344 +
288 ST- 04	345 LASTX
289 RCL 22	346 1
290 RCL 20	347 X<>Y
291 *	348 -
292 ST- 05	349 /
293 RCL 20	350 LN
294 *	351 2
295 ST- 06	352 /
296 GTO 02	353 -
297*LBL G	354 RTN
298 XEQ 18	355*LBL 19
299 RCL 19	356 RCL 20
300 3	357 ABS
301 -	358 STO 20
302 SQRT	359 1
303 *	360 RCL 20
304 SF 13	361 ,196854
305 "U"	362 *
306 XEQ 11	363 +
307 STO 20	364 RCL 20
308 CF 13	365 X+2
309 GTO 19	366 ,115194
310*LBL H	367 *
311 STOP	368 +
312 STO 00	369 RCL 20
313 XEQ 18	370 3
314 STOP	371 Y+X
315 3	372 ,000344
316 -	373 *
317 1/X	374 +
318 STOP	375 RCL 20
319 3	376 4
320 -	377 Y+X
321 1/X	378 ,019527
322 +	379 *
323 SQRT	380 +
324 /	381 -4
325 STO 20	382 Y+X
326 SF 13	383 2
327 "U"	384 /
328 XEQ 11	385 CHS
329 CF 13	386 1
330 GTO 19	387 +
331*LBL 18	388 1
332 1	389 X<>Y
333 RCL 00	390 -
334 +	391 FIX 3
335 1	392 2
336 RCL 00	393 *
337 -	394 "P"
338 /	395 XEQ 11
339 LN	396 FIX 2
340 2	397 RTN
341 /	398 END
342 1	

REGISTERS, STATUS, FLAGS
REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers Datenspeicher Registres de données Registri				Status Betriebsart Modes opératoires Modi operativi			
				Size <u>026</u> Total Reg. _____		User Mode	
				Eng ☐	Fix ☒	Sci ☐	On ☒
				Deg ☐	Rad ☒	Grad ☐	Off ☐
00	r 12	50		Purpose Bedeutung Signification Scopo			
	n - 2						
	$\sum f y_1' y_2'$			Flags SET CLEAR			
	$\sum f y_2'$						
05	$\sum f y_2'$	55		00	Grouped data	☒	
	$\sum f y_1'$			01	P(t)	☒	
	$\sum f y_1'$			02			
10	t	60		03	P(u)	☒	
				04			
				05			
				06			
	statistic			07			
15	stack	65		08			
	.			09			
	.			10			
	.			11	Audio execute		
	$\sum f$			12			
20	$y_1' ; u$	70		13			
	y_2'			14			
	f			15			
				16			
				17			
25		75		18			
				19			
				20			
				21	Printer Enable		
				22	Number Input		
30		80		23	Alpha Input		
				24	Range Ignore		
				25	Error Ignore		
				26	Audio Enable		
				27	User Mode		
35		85		28	Decimal Point		
				29	Digit Grouping		
				Assignments Tastenbelegung / Assignations / Assegnamenti			
40		90		Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto
45		95					
		99					

LINEAR REGRESSIONDESCRIPTION

When dealing with a functional relationship between two variables, we try to adjust the data to a function which is a regression equation. The most generally used is :

$$Y = a + bX$$

which describes a linear relationship between X , supposed to be fixed and measured without error, and Y , random variable. X is called the independent variable and Y the dependent variable. a is the Y -intercept and b the slope of the line, or regression coefficient.

For each of the k values of X , we have, either only one value of Y , or n responses Y for each X . In the first case, the line is adjusted through the Y points; in the second case through the means of the n responses. The line passes through the point $(\bar{x}, \bar{y})$, and can be computed by the method of least squares. The regression coefficient is :

$$b = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sum (x - \bar{x})^2} = \frac{S.P. \ xy}{S.S. \ x}$$

The Y -intercept is : $a = \bar{y} - bx$.

The quality of the adjustment of the experimental points to the calculated line can be tested; each point differs from the point $\hat{y}$ calculated with the equation by a quantity $(y - \hat{y}) = d$. The method of least squares is such as $\sum d^2$ is a minimum. The total sum of squares of Y is equal to the sum of this $\sum d^2$, called the unexplained S.S. and the explained S.S. due to regression. We can compute :

$$\text{Total S.S.} = \sum y^2 - (\sum y)^2/k$$

$$\text{Explained S.S.} = b \cdot S.P.xy$$

The S.S. of the deviations from the regression are obtained by difference and the results presented as a table of ANOVA

STAT.14

Source of variation	d.f.	S.S.	Mean square	F
Regression	1	.	s_R^2	s_R^2/s_d^2
Deviation from regression	(k - 2)	.	s_d^2	
Total	(k - 1)	.		

This ANOVA is used to test $H_0: \beta = 0$

β being the parametric value of the estimated regression coefficient b.

When we have k groups of n measurements, with mean $\bar{y}$, d is the deviation of the experimental means from the computed $\hat{y}$ for each value of X; another source of variation is the dispersion of the experimental points around each mean $\bar{y}$ (experimental error). We compute, as before, the total S.S. (1) and the S.S. due to regression (2), and the S.S. between groups, with the group totals T_g :

$$\text{S.S. groups} = \sum T_g^2/n - \text{C.F.} \quad (3)$$

$$\text{S.S. deviation} = (3) - (2)$$

$$\text{S.S. error} = (1) - (3)$$

The ANOVA is :

Source of variation	d.f.	S.S.	Mean square	F
Regression	1	.	s_R^2	s_R^2/s_d^2
Deviation from regression	(k - 2)	.	s_d^2	s_d^2/s_E^2
Between groups	(k - 1)	.		
Within groups (error)	k(n-1)	.	s_E^2	
Total	(kn-1)	.		

The first F tests $H_0: \beta = 0$

The second F tests the mean square of deviation from regression over the within group M.S. (error); if it is significant, it means that the relationship between Y and X is not linear. In this case, a suitable transformation of the variable(s) may linearize at least a portion of the curve. The program provides a transformation of X into $\log X$, which is a convenient transformation in many biological problems. If s_d^2 is not significant, the program pools it with the error variance s_E^2 to provide a larger number of d.f.

Use of regression

1 - The regression equation can be used to predict a value $\hat{Y}$, for a given value of X . The standard error $s_{\hat{Y}}$ is :

$$s_{\hat{Y}} = \sqrt{s_d^2 \left[\frac{1}{N} + \frac{(X - \bar{x})^2}{\sum (x - \bar{x})^2} \right]}$$

and the confidence limits : $\hat{Y} \pm t_{0,05} s_{\hat{Y}}$

By computing the confidence limits for several values of X , the confidence limit of the regression line can be established.

2 - Frequently, the regression is used to estimate X from a value of Y or of the mean $\bar{y}$ (standard or calibration line). The equation is used in the form :

$$\hat{X} = (Y - a)/b$$

The standard error of $\hat{X}$ is :

$$s_{\hat{X}} = \sqrt{\frac{s^2}{b^2} \left[\left(\frac{1}{m} + \frac{1}{N} \right) + \frac{(Y - \bar{y})^2}{b^2} \cdot \frac{1}{\sum (x - \bar{x})^2} \right]}$$

m is the number of responses of Y .

The approximate confidence limits are : $\hat{X} \pm t_{0,05} s_{\hat{X}}$

The program can compute these two values and their confidence interval.

CONTENTS

VOLUME II

Number	Title	Initial	Nber memory modules	Nber cards & tracks
STAT.10	Two-way ANOVA	ANVA 6	2	4 (1 to 7)
11	Three-factor ANOVA	ANVA 7	2	3 (1 to 6)
12	Three, four and five factors at two levels	ANVA 8	2	4 (1 to 7)
13	Correlation coefficient	CORR.	1	3 (1 to 6)
14	Linear regression	REGE	2	4 (1 to 8)
15	Analysis of covariance	ANCOVA	2	4 (1 to 8)
16				
17	Non parametric rank tests	RANG	2	3 (1 to 6)
18	Non parametric frequency tests	FREQ	2	4 (1 to 7)

USER INSTRUCTIONS I

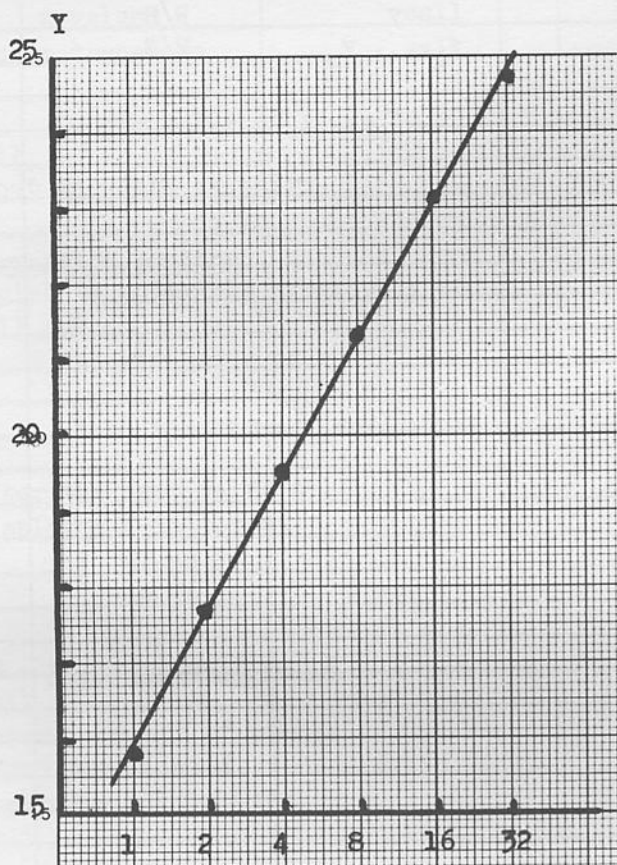
STAT.14

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.14, tracks 1 to 8			
2	Initialize		XEQ "REGR"	
3	x values call		A	
	or log.x transform call		F	
	<u>1 - one value of Y per X</u>			
4	Call		D	
5	Input the data by pairs	x_i	R/S	
		y_i	R/S	
6	<u>Correction routine</u>			
	Finish to enter the wrong pair and call		E	
	input the erroneous pair	x_E	R/S	
		y_E	R/S	
	then the correct one			
7	After the last pair, call		G	
	Display : Y-intercept			a
	slope			b
	ANOVA			
	<u>2 - n responses Y per X</u>			
8	Call		C	
9	Enter : number of groups	k	R/S	
10	Input the first X	x	R/S	
11	Input the n responses	y_i	R/S	
12	Call		B	ΣY
13	Display : group total T _j Repeat steps 10 to 12 for the other values of X			
14	<u>Correction routine</u>			
	Call		E	
	input the erroneous y then the correct one	y_E	R/S	
15	After the last group, call		G	
	Display : Y-intercept	a	R/S	a
	slope			b
	ANOVA			
	<u>Estimation of $\hat{Y}$</u>			
16	Call		H	
17	Enter the value X	x	R/S	Y
	Display : calculated $\hat{Y}$ 95 % confidence interval			L.I.
18	Repeat step 17 for other values of X			L.S.

EXAMPLE 1 - One value of Y for each X. Log. transform.

X :	1	2	4	8	16	32
Y :	15,87	17,78	19,52	21,35	23,13	24,77



ANVA

REG.

D.L.=1,00

S.C.=55,59

C.M.=55,59

F=9,906,16

P=1,421E-4

DEV.

D.L.=4,00

S.C.=0,02

C.M.=0,01

TOT.

D.L.=5,00

S.C.=55,61

Estimation $\hat{Y}$ Estimation $\hat{X}$

XEQ "REGR"
XEQ F
XEQ D

1,00 RUN
15,87 RUN

2,00 RUN
17,78 RUN

4,00 RUN
19,52 RUN

(error) 18,00 RUN
21,35 RUN

XEQ E
18,00 RUN
21,35 RUN
8,00 RUN
21,35 RUN

16,00 RUN
23,13 RUN

32,00 RUN
24,77 RUN

XEQ G

a=15,95
b=5,92

XEQ H
10,00 RUN

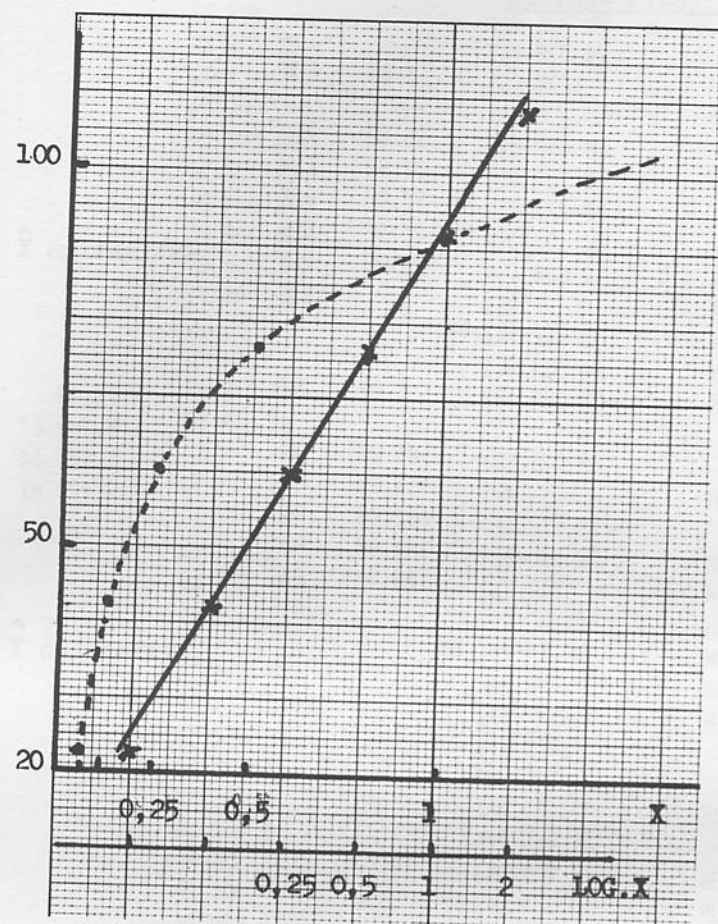
Y=21,87
S.E.Y=0,03
L.I.=21,77
L.S.=21,96

XEQ I
20,00 RUN

X=4,84
S.E.X=0,01

L.I.=4,43
L.S.=5,28

EXAMPLE 2 - n responses Y for each X (*)



```

XEQ "REGR"
XEQ A
XEQ C
6.00 RUN
0.0625 RUN
22.00 RUN
22.00 RUN
27.00 RUN
23.00 RUN
21.00 RUN
XEQ B
ΣY.=115.00

0.125 RUN
47.00 RUN
41.00 RUN
44.00 RUN
38.00 RUN
45.00 RUN
XEQ B
ΣY.=215.00

0.250 RUN
58.00 RUN
163.00 RUN
58.00 RUN
58.00 RUN
66.00 RUN
XEQ E
163.00 RUN
63.00 RUN
XEQ B
ΣY.=303.00

0.50 RUN
78.00 RUN
79.00 RUN
78.00 RUN
77.00 RUN
74.00 RUN
XEQ B
ΣY.=386.00
    
```

```

1.00 RUN
96.00 RUN
91.00 RUN
97.00 RUN
85.00 RUN
92.00 RUN
XEQ B
ΣY.=461.00
    
```

```

2.00 RUN
109.00 RUN
114.00 RUN
111.00 RUN
104.00 RUN
109.00 RUN
XEQ B
ΣY.=547.00
    
```

```

a=42.37
b=38.40
XEQ C
    
```

```

ANVA
REG.
D.L.=1.00
S.C.=20.258.40
C.M.=20.258.40
F=15.64
P=0.018
DEV.
D.L.=4.00
S.C.=5.180.97
C.M.=1.295.24
F=108.69
P=2.780E-8
    
```

```

ERR.
D.L.=24.00
S.C.=286.00
C.M.=11.92
TOT.
D.L.=29.00
S.C.=25.725.37
    
```


STAT.14

PROGRAM LISTING

 PROGRAMMAUFLISTUNG
 LISTAGE DU PROGRAMME
 LISTATO DI PROGRAMMA

01*LBL "REGR"	58 X<>Y	115 RCL 12	172 FS? 01	229 E-
02*LBL a	59 STO 01	116 RCL 04	173 GTO 05	230 RCL 25
03 CF 00	60 RCL 15	117 -	174 RCL 22	231 1
04 CF 01	61 RCL 14	118 STO 05	175 /	232 -
05 RTN	62 X+2	119 XEQ 06	176 STO 16	233 STO 25
06*LBL F	63 RCL 19	120 RCL 05	177 "F"	234 GTO 00
07 SF 00	64 /	121 X<>Y	178 XEQ 11	235*LBL 08
08*LBL A	65 -	122 /	179 RCL 08	236 STOP
09 CLRG	66 STO 10	123 STO 06	180 STO 26	237 FS? 00
10 RTN	67 RCL 18	124 FS? 01	181 XEQ 10	238 LOG
11*LBL D	68 RCL 14	125 GTO 04	182 "ERR."	239 STOP
12 SF 01	69 RCL 16	126 RCL 12	183 AVIEW	240 X<>Y
13*LBL 01	70 *	127 RCL 13	184 RCL 08	241 E-
14 STOP	71 RCL 19	128 -	185 "D.L."	242 GTO 01
15 FS? 00	72 /	129 STO 07	186 XEQ 11	243*LBL 11
16 LOG	73 -	130 RCL 19	187 RCL 07	244 "I="
17 STOP	74 STO 11	131 RCL 20	188 "S.C."	245 ARCL X
18 ADV	75 RCL 10	132 -	189 XEQ 11	246 AVIEW
19 X<>Y	76 /	133 STO 08	190 "C.M."	247 RTN
20 ΣREG 14	77 STO 21	134 /	191 RCL 22	248*LBL 06
21 Σ+	78 RCL 16	135 STO 22	192 XEQ 11	249 RCL 20
22 GTO 01	79 RCL 21	136*LBL 04	193 ADV	250 FS? 01
23*LBL C	80 RCL 14	137 ADV	194*LBL 05	251 RCL 19
24 CLF^	81 *	138 "ANVA"	195 FS? 01	252 2
25 STOP	82 -	139 AVIEW	196 ADV	253 -
26 STO 20	83 RCL 19	140 ADV	197 "TOT."	254 RTN
27 ADV	84 /	141 "REG."	198 AVIEW	255*LBL 10
28*LBL 02	85 STO 23	142 AVIEW	199 RCL 19	256 2
29 STOP	86 SF 13	143 1	200 1	257 ENTER↑
30 FS? 00	87 "A"	144 "D.L."	201 -	258 9
31 LOG	88 XEQ 11	145 XEQ 11	202 "D.L."	259 /
32 STO 21	89 RCL 21	146 STO 24	203 XEQ 11	260 STO 28
33 ADV	90 "B"	147 RCL 04	204 RCL 12	261 RCL 24
34*LBL 00	91 XEQ 11	148 "S.C."	205 "S.C."	262 /
35 STOP	92 CF 13	149 XEQ 11	206 XEQ 11	263 STO 25
36 ST+ 00	93 ADV	150 "C.M."	207 RCL 09	264 RCL 28
37 RCL 21	94 RCL 17	151 XEQ 11	208 ,05	265 RCL 26
38 ΣREG 14	95 RCL 16	152 RCL 06	209 X<>Y?	266 /
39 Σ+	96 X+2	153 /	210 GTO 00	267 STO 28
40 7ISZ	97 RCL 19	154 STO 16	211 7	268 1
41 GTO 00	98 /	155 "F"	212 RCL 05	269 -
42*LBL B	99 STO 22	156 XEQ 11	213 RCL 07	270 CHS
43 RCL 00	100 -	157 XEQ 06	214 +	271 RCL 16
44 "ΣY."	101 STO 12	158 STO 26	215 RCL 19	272 3
45 XEQ 11	102 FS? 01	159 XEQ 10	216 2	273 1/X
46 ADV	103 GTO 03	160 "DEV."	217 -	274 Y+X
47 X+2	104 RCL 02	161 AVIEW	218 STO 24	275 *
48 RCL 25	105 RCL 22	162 XEQ 06	219 /	276 1
49 /	106 -	163 STO 24	220 STO 06	277 RCL 25
50 ST+ 02	107 STO 13	164 "D.L."	221*LBL 07	278 -
51 6	108*LBL 03	165 XEQ 11	222 RTN	279 -
52 STO 00	109 RCL 11	166 RCL 05	223*LBL E	280 STO 27
53 STO 25	110 RCL 21	167 "S.C."	224 FS? 01	281 RCL 28
54 GTO 02	111 *	168 XEQ 11	225 GTO 08	282 RCL 16
55*LBL G	112 STO 04	169 RCL 06	226 STOP	283 2
56 MEAN	113 RCL 13	170 "C.M."	227 ST- 00	284 ENTER↑
57 STO 00	114 FS? 01	171 XEQ 11	228 RCL 21	285 3

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.14

286 /	343*LBL 13	400*LBL 14	457 FS? 00
287 Y+X	344 RCL 23	401 STOP	458 10+X
288 *	345 RCL 21	402 STO 17	459 "L.S."
289 RCL 25	346 STOP	403*LBL 16	460 XEQ 11
290 +	347 FS? 00	404 RCL 23	461 ADV
291 SQRT	348 LOG	405 -	462 GTO I
292 RCL 27	349 STO 15	406 RCL 21	463*LBL 19
293 X<>Y	350 *	407 /	464 2,3777
294 /	351 +	408 STO 18	465 RCL 24
295 STO 28	352 -Y"	409 FS? 00	466 /
296 X>0?	353 XEQ 11	410 10+X	467 E+X
297 SF 02	354 STO 16	411 "X"	468 ,96
298 ABS	355 RCL 15	412 XEQ 11	469 +
299 1	356 RCL 00	413 FS? 01	470 RTN
300 RCL 28	357 -	414 GTO 17	471 ADV
301 ,196854	358 X+2	415 RCL 25	472 .END.
302 *	359 RCL 10	416 1/X	
303 +	360 /	417 RCL 19	
304 RCL 28	361 RCL 19	418 1/X	
305 X+2	362 1/X	419 +	
306 ,115194	363 +	420 GTO 18	
307 *	364 RCL 06	421*LBL 17	
308 +	365 *	422 1	
309 RCL 28	366 SQRT	423 RCL 19	
310 3	367 "S.E.Y"	424 1/X	
311 Y+X	368 XEQ 11	425 +	
312 ,00034	369 XEQ 19	426*LBL 18	
313 *	370 *	427 RCL 17	
314 +	371 RCL 16	428 RCL 01	
315 RCL 28	372 X<>Y	429 -	
316 4	373 ST+ 16	430 X+2	
317 Y+X	374 -	431 RCL 21	
318 ,019527	375 "L.I."	432 X+2	
319 *	376 XEQ 11	433 /	
320 +	377 RCL 16	434 RCL 10	
321 -4	378 "L.S."	435 /	
322 Y+X	379 XEQ 11	436 +	
323 2	380 ADV	437 RCL 06	
324 /	381 GTO 13	438 RCL 21	
325 CHS	382*LBL I	439 X+2	
326 1	383 0	440 /	
327 +	384 STO 17	441 *	
328 FIX 3	385 STO 25	442 SQRT	
329 FS?C 02	386 FS? 01	443 "S.E.X"	
330 XEQ 12	387 GTO 14	444 XEQ 11	
331 "P"	388*LBL 15	445 ADV	
332 XEQ 11	389 STOP	446 XEQ 19	
333 STO 09	390 ST+ 17	447 *	
334 FIX 2	391 7ISZ	448 RCL 18	
335 ADV	392 GTO 15	449 X<>Y	
336 RTN	393*LBL J	450 ST+ 18	
337*LBL 12	394 ADV	451 -	
338 1	395 RCL 17	452 FS? 00	
339 X<>Y	396 RCL 25	453 10+X	
340 -	397 /	454 "L.I."	
341 RTN	398 STO 17	455 XEQ 11	
342*LBL H	399 GTO 16	456 RCL 18	

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers Datenspeicher Registres de données Registri				Status Betriebsart Modes opératoires Modi operativi			
00	$\bar{i}$ y	50		Size <u>030</u> Total Reg. _____		User Mo	
				Eng ☐	Fix ☒	Sci ☐	On ☒
				Deg ☐	Rad ☐	Grad ☐	Off ☐
	S.S.regression			Purpose Bedeutung Signification Scopo		Flags	
05	S.S.deviation	55				SET	CLEAR
	M.S.deviation						
	S.S.error			00	log.x	☒	
	d.f.error			01	one X per X	☒	
	P			02	P(F) routine	☒	
10	S.S. x	60		03			
	S.P. xy			04			
	Total S.S.			05			
	Group S.S.			06			
	Σx			07			
15	Σx^2	65		08			
	F			09			
	Σy^2			10			
	Σxy			11	Audio execute		
	Σn			12			
20	k	70		13			
	b			14			
	M.S.error			15			
	a			16			
	d.f.1			17			
25		75		18			
	d.f.2			19			
	F routine			20			
	.			21	Printer Enable		
	.			22	Number Input		
30		80		23	Alpha Input		
				24	Range Ignore		
				25	Error Ignore		
				26	Audio Enable		
				27	User Mode		
35		85		28	Decimal Point		
				29	Digit Grouping		
				Assignments Tastenbelegung/Assignations/Assegnamenti			
40		90		Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto
45		95					
		99					

ANALYSIS OF COVARIANCE

DESCRIPTION

Analysis of covariance combines the advantages of analysis of variance and of regression. When a variable Y, which will be analysed by a single classification ANOVA, is supposed to be related to another variable X, which cannot be kept constant, but which can be measured, it is possible, by the analysis of covariance (ANCOVA), to evaluate the influence of X on Y. If X, the concomitant variable, is related to Y by a linear regression with coefficient β , the ANCOVA is used to "adjust" the means of the a treatments $\bar{y}$.

For each observation, we have a pair of data x_i and y_i , from which we compute the sums of squares on X and on Y, in order to construct an ANOVA table of these two variables, and the sum of products XY, to complete the ANCOVA table. The S.P. are :

$$\text{Total S.P. : } \sum (x - \bar{x})(y - \bar{y}) = \sum xy - \sum x \sum y / \sum n$$

$$\text{Treatment S.P. : } \sum (\sum x \sum y) - \sum x \sum y / \sum n$$

Error S.P. : by difference

Source of variation	d.f.	S.S. X	S.P. XY	S.S. Y
Total	(an - 1)	$\sum xx$	$\sum xy$	$\sum yy$
Treatments	(a - 1)	Txx	Txy	Tyy
Error	a(n-1)	Exx	Exy	Eyy
Regression	1		$(Exy)^2 / Exx =$	L^2
Error adj.	a(n-1)-1		$Eyy - L^2 =$	Ex.y

The relationship between Y and X is estimated by computing a regression coefficient, using the S.S. and S.P. of the error of the ANCOVA, to eliminate the influence of the treatments, if any :

$$b_x = Exy / Exx$$

the S.S. due to regression, with 1 d.f., is :

$$L^2 = (E_{xy})^2 / E_{xx}$$

By removing this quantity from the error SS E_{yy} , we obtain a S.S. of error adjusted for the regression. This new S.S. ($E_{x.y}$) has one d.f. less than the unadjusted S.S.; an error mean square is computed from these quantities ($s^2_{x.y}$)

A test of the hypothesis $H_0: \beta=0$ (there is no relationship between X and Y) is :

$$F = L^2 / s^2_{x.y}$$

If β does not differ significantly from zero, the ANCOVA has no advantage over a simple ANOVA. If b is significant, the treatment S.S. is adjusted to test the difference between treatments:

$$F = \text{M.S. tr. adj.} / s^2_{x.y}$$

and the means of the a treatments are adjusted :

$$\bar{y}_{\text{adj.}} = \bar{y} - b (\bar{x} - \bar{\bar{x}})$$

These $\bar{y}_{\text{adj.}}$ are the means that we should have observed, if we had been able to keep all the x_i values constant at the $\bar{\bar{x}}$ level.

The adjusted means can be compared, using an error term slightly larger than $s^2_{x.y}$, to take in account the error on b :

$$s'^2 = s^2_{x.y} \left(1 + \frac{t_{xx}}{E_{xx}} \right)$$

$t_{xx} = T_{xx} / (a - 1)$. The program provides a "t" test using this error term.

TWO-WAY ANALYSIS OF VARIANCE

WITH REPLICATION

Two factors A and B are evaluated at the same time, the first at a levels, the second at b levels, representing ab combinations (treatments). Each treatment is replicated n times, yielding a total of abn responses. The program can handle up to 10 levels of factor A; if a is larger than 10, a signal ERROR is displayed.

In this type of ANOVA, the variation due to treatments is divided into

- the main effects of A and B
- an interaction AxB

If this interaction is not significant, the two factors are said independent, and can be studied separately.

Factor B (b = 2)	Factor A (a = 3)			T_b
	A_1	A_2	A_3	
B_1	$\left. \begin{matrix} - \\ - \end{matrix} \right\} T_g$	-	-	T_a
B_2	-	-	-	

(n = 2)

The ANOVA table is :

Source of variation	Number of d.f.	Sum of squares	Mean square	F
Factor A	(a - 1)		s_A^2	F_A
Factor B	(b - 1)		s_B^2	F_B
Interaction	(a - 1)(b - 1)		s_{AB}^2	F_{AB}
Error	ab(n - 1)		s_E^2	
Total	(abn - 1)			

A two-way ANOVA may be of different kinds :

- A and B are fixed treatments : Model I ANOVA
- A and B are random : Model II ANOVA
- A is fixed, B is random : Mixed Model ANOVA

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.15, tracks 1 to 8			
2	Initialize		XEQ"ANCOVA"	
3	Enter : number of treatments	a	R/S	
4	Input the data of the first group by pairs	x_1 y_1	R/S R/S	
5	Correction routine Finish to enter the wrong pair and call input the erroneous pair	x_E y_E	E R/S R/S	
6	then the correct one After the last pair of the group, call Display : sum of X mean X sum of Y mean Y		B	$\sum X$ MOY.X $\sum Y$ MOY.Y
7	Repeat steps 4 to 6 for the other groups			
8	After the last group, display of the ANCOVA			
9	Display : regression coefficient			b_x
	Test $\beta = 0$? F P(F)			F P
10	Test : difference among treatments Adjusted S.S. y " M.S. y F P(F)			S.C. C.M. F P MOY.
11	Display : Adjusted means			
12	Test : difference of means Display : corrected standard dev. Input : the means to be compared the sample sizes Display : calculated "t" limit value "t" _{0,05}	$\bar{y}_1$ $\bar{y}_2$ n_1 n_2	R/S R/S R/S R/S	s t t _{0,05}
13	Repeat 12 for another comparison			
14	For another set of data, call and return to step 3		A	

EXAMPLE 1 - (*)

XEQ "ANCOVA"
3.00 RUN

1.50 RUN
26.80 RUN
3.00 RUN
24.20 RUN
4.20 RUN
25.80 RUN
3.10 RUN
23.50 RUN
7.60 RUN
19.90 RUN
2.50 RUN
25.30 RUN
2.20 RUN
26.20 RUN
1.40 RUN
24.80 RUN

XEQ B

$\Sigma X = 25.50$
 $MOY. X = 3.19$
 $\Sigma Y = 196.50$
 $MOY. Y = 24.56$

3.40 RUN
29.30 RUN
2.60 RUN
27.90 RUN
2.40 RUN
32.10 RUN
4.90 RUN
24.10 RUN
1.80 RUN
24.60 RUN
8.20 RUN
24.40 RUN
2.90 RUN
29.70 RUN
3.20 RUN
35.40 RUN

XEQ B

$\Sigma X = 29.40$
 $MOY. X = 3.68$
 $\Sigma Y = 227.50$
 $MOY. Y = 28.44$

(error)

1.80 RUN
32.50 RUN
2.30 RUN
29.20 RUN
7.00 RUN
30.40 RUN
11.90 RUN
22.50 RUN
13.40 RUN
27.30 RUN
13.40 RUN
27.30 RUN
3.40 RUN
27.30 RUN
2.60 RUN
37.90 RUN
2.80 RUN
30.80 RUN
3.10 RUN
29.50 RUN

XEQ E

XEQ B

$\Sigma X = 34.90$
 $MOY. X = 4.36$
 $\Sigma Y = 240.10$
 $MOY. Y = 30.01$
ANVA
TOT.
D.L. = 23.00
S.C. X = 145.44
S.C. Y = 406.93
S.P. XY = -97.66

TRAIT
D.L. = 2.00
S.C. X = 5.58
S.C. Y = 125.86
S.P. XY = 25.00

ERR.
D.L. = 21.00
S.C. X = 139.86
S.C. Y = 281.07
S.P. XY = -122.66

REGR
D.L. = 1.00
S.C. Y = 107.58

ERR. 2
D.L. = 20.00
S.C. = 173.49
C.M. = 8.67

$b = -0.87702$
 $F = 12.40$
 $P = 0.002$

TRAIT. AJ.
S.C. = 167.86
C.M. = 83.93
 $F = 9.68$
 $P = 0.001$

 $MOY. = 24.08$ $MOY. = 28.38$ $MOY. = 30.56$ $s = 2.97$

24.08 RUN
28.38 RUN
8.00 RUN
8.00 RUN

 $t = 2.89$ $t.0,05 = 2.09$

24.08 RUN
30.56 RUN
8.00 RUN
8.00 RUN

 $t = 4.36$ $t.0,05 = 2.09$

PROGRAM LISTING

STAT.15

PROGRAMMAUFLISTUNG

LISTAGE DU PROGRAMME

LISTATO DI PROGRAMMA

01*LBL "ANCOVA"	58 RCL 19	115 RCL 12	172 1	229 RCL 20
02*LBL A	59 /	116 RCL 22	173 -	230 RCL 00
03 CLRG	60 "MOY.Y"	117 XEQ 07	174 STO 07	231 /
04 STOP	61 STO IND 26	118 STO 12	175 "D.L."	232 STO 24
05 STO 00	62 ISG 26	119 XEQ 11	176 XEQ 11	233 XEQ 12
06 XEQ 12	63 XEQ 11	120 "S.P.XY"	177 RCL 13	234*LBL 05
07 ADV	64 RCL 19	121 RCL 05	178 RCL 09	235 RCL 27
08*LBL 02	65 STO IND 26	122 XEQ 04	179 -	236 RCL IND 26
09 ΣREG 14	66 ISG 26	123 STO 06	180 "S.C."	237 RCL 24
10 CLΣ	67 ADV	124 XEQ 11	181 XEQ 11	238 -
11 7ISZ	68 RCL 25	125 ADV	182 STO 29	239 *
12 RCL 25	69 RCL 08	126 "ERR."	183 X<>Y	240 ISG 26
13 CF 13	70 X*Y?	127 AVIEW	184 /	241 RCL IND 26
14*LBL 01	71 GTO 02	128 "D.L."	185 "C.M."	242 X<>Y
15 STOP	72 "ANVA"	129 RCL 00	186 XEQ 11	243 -
16 STOP	73 AVIEW	130 RCL 25	187 STO 23	244 "MOY."
17 X<>Y	74 ADV	131 -	188 ADV	245 XEQ 11
18 Σ+	75 "TOT."	132 STO 07	189 RCL 27	246 ADV
19 STO 09	76 AVIEW	133 XEQ 11	190 FIX 5	247 ISG 26
20 GTO 01	77 RCL 00	134 "S.C.X"	191 SF 13	248 ISG 26
21*LBL B	78 1	135 RCL 01	192 "B"	249 GTO 05
22 RCL 14	79 -	136 RCL 02	193 XEQ 11	250*LBL D
23 ST+ 20	80 "D.L."	137 -	194 CF 13	251 RCL 23
24 RCL 15	81 XEQ 11	138 STO 03	195 FIX 2	252 RCL 02
25 ST+ 21	82 "S.C.X"	139 XEQ 11	196 "F"	253 RCL 25
26 RCL 16	83 RCL 21	140 "S.C.Y"	197 RCL 09	254 1
27 ST+ 22	84 RCL 20	141 RCL 11	198 RCL 23	255 -
28 RCL 17	85 XEQ 07	142 RCL 12	199 /	256 /
29 ST+ 23	86 STO 01	143 -	200 STO 19	257 RCL 03
30 RCL 18	87 XEQ 11	144 STO 13	201 XEQ 11	258 /
31 ST+ 24	88 "S.C.Y"	145 XEQ 11	202 1	259 1
32 RCL 09	89 RCL 23	146 "S.P.XY"	203 STO 16	260 +
33 ST+ 00	90 RCL 22	147 RCL 14	204 XEQ 13	261 *
34 RCL 14	91 XEQ 07	148 RCL 06	205 "TRAIT.AJ."	262 SQRT
35 XEQ 08	92 STO 11	149 -	206 AVIEW	263 SF 13
36 ST+ 02	93 XEQ 11	150 STO 16	207 RCL 14	264 "S"
37 RCL 16	94 "S.P.XY"	151 XEQ 11	208 X+2	265 XEQ 11
38 XEQ 08	95 RCL 24	152 ADV	209 RCL 01	266 STO 23
39 ST+ 12	96 XEQ 04	153 RCL 16	210 /	267*LBL 03
40 RCL 14	97 STO 14	154 RCL 03	211 RCL 11	268 CF 13
41 RCL 16	98 XEQ 11	155 /	212 -	269 STOP
42 *	99 ADV	156 STO 27	213 CHS	270 STOP
43 RCL 19	100 "TRAIT"	157 "REGR"	214 RCL 29	271 -
44 /	101 AVIEW	158 AVIEW	215 -	272 ABS
45 ST+ 05	102 RCL 25	159 "D.L."	216 "S.C."	273 RCL 23
46 RCL 14	103 1	160 1	217 XEQ 11	274 STOP
47 "ΣX"	104 -	161 XEQ 11	218 RCL 04	275 1/X
48 XEQ 11	105 STO 04	162 RCL 27	219 STO 16	276 STOP
49 RCL 19	106 "D.L."	163 RCL 16	220 /	277 1/X
50 /	107 XEQ 11	164 *	221 "C.M."	278 +
51 "MOY.X"	108 "S.C.X"	165 "S.C.Y"	222 XEQ 11	279 SQRT
52 XEQ 11	109 RCL 02	166 XEQ 11	223 RCL 23	280 *
53 STO IND 26	110 RCL 20	167 STO 09	224 /	281 /
54 ISG 26	111 XEQ 07	168 ADV	225 "F"	282 SF 13
55 RCL 16	112 STO 02	169 "ERR.2"	226 XEQ 11	283 "T"
56 "ΣY"	113 XEQ 11	170 AVIEW	227 STO 19	284 XEQ 11
57 XEQ 11	114 "S.C.Y"	171 RCL 07	228 XEQ 13	285 ADV

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.15

286 2,3777	343 9	400 RCL 22
287 RCL 07	344 /	401 4
288 /	345 STO 15	402 Y↑X
289 E↑X	346 RCL 16	403 ,019527
290 ,96	347 /	404 *
291 +	348 STO 17	405 +
292 "T.0,05"	349 RCL 15	406 -4
293 XEQ 11	350 RCL 07	407 Y↑X
294 ADV	351 /	408 2
295 GTO 03	352 STO 15	409 /
296 RTN	353 1	410 CHS
297*LBL 04	354 -	411 1
298 RCL 20	355 CHS	412 +
299 RCL 22	356 RCL 19	413 FIX 3
300 *	357 3	414 FS?C 02
301 RCL 00	358 1/X	415 XEQ 14
302 /	359 Y↑X	416 "P"
303 -	360 *	417 XEQ 11
304 RTN	361 1	418 FIX 2
305*LBL 06	362 RCL 17	419 ADV
306 RCL 02	363 -	420 RTN
307 RCL 25	364 -	421*LBL 14
308 1	365 STO 21	422 1
309 -	366 RCL 15	423 X<>Y
310 /	367 RCL 19	424 -
311 RTN	368 2	425 RTN
312*LBL 07	369 ENTER↑	426*LBL E
313 X↑2	370 3	427 STOP
314 RCL 00	371 /	428 STOP
315 /	372 Y↑X	429 X<>Y
316 -	373 *	430 Σ-
317 RTN	374 RCL 17	431 GTO 01
318*LBL 08	375 +	432 .END.
319 X↑2	376 SQRT	
320 RCL 19	377 RCL 21	
321 /	378 X<>Y	
322 RTN	379 /	
323*LBL 11	380 STO 22	
324 "I="	381 X>0?	
325 ARCL X	382 SF 02	
326 AVIEW	383 ABS	
327 RTN	384 1	
328*LBL 12	385 RCL 22	
329 RCL 08	386 ,196854	
330 3	387 *	
331 *	388 +	
332 29	389 RCL 22	
333 +	390 X↑2	
334 1000	391 ,115194	
335 /	392 *	
336 30	393 +	
337 +	394 RCL 22	
338 STO 26	395 3	
339 RTN	396 Y↑X	
340*LBL 13	397 ,000344	
341 2	398 *	
342 ENTER↑	399 +	

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers Datenspeicher Registres de données Registri				Status Betriebsart Modes opératoires Modi operativi			
				Size 055 Total Reg.		User Mode	
00	n	50		Eng ☐	Fix ☒	Sci ☐	On ☒
	total SS X			Deg ☐	Rad ☐	Grad ☐	Off ☐
	treat.SS X			Purpose Bedeutung Signification Scopo			
	error SS X						
05	treat. d.f. ($\sum x \sum y$)	55		Flags SET CLEAR			
	treat. SP						
	error d.f.			00			
	a			01			
	L ²			02	P(F) routine	X	
10		60		03			
	total SS Y			04			
	treat.SS Y			05			
	error SS Y			06			
	total SP			07			
15		65		08			
	error SP			09			
				10			
				11	Audio execute		
				12			
20	$\sum x$	70		13			
	$\sum x^2$			14			
	$\sum y$			15			
	$\sum y^2, \text{err.s}^2$			16			
	$\sum xy; \bar{x}$			17			
25		75		18			
				19			
	b			20			
	adj.treat.SS			21	Printer Enable		
30	$\bar{y}_1$	80		22	Number Input		
	n_1			23	Alpha Input		
	.			24	Range Ignore		
	.			25	Error Ignore		
	.			26	Audio Enable		
35	.	85		27	User Mode		
				28	Decimal Point		
				29	Digit Grouping		
				Assignments Tastenbelegung / Assignations / Assegnamenti			
40		90		Function	Key	Function	Key
				Funktion	Taste	Funktion	Taste
				Fonction	Touche	Fonction	Touche
				Funzione	Tasto	Funzione	Tasto
45		95					
		99					

NON-PARAMETRIC RANK TESTSDESCRIPTION

When the conditions of the parametric tests are not fulfilled, i.e. when the data are :

- on an ordinal scale (scores)
- or measured variables known not to be normally distributed
- or when the variances of the several groups are not identical (heteroscedasticity)

these tests ("t" tests and analysis of variance) can be replaced by non parametric tests, in which the data are replaced by their rank.

The data are ranked in order of increasing size; when two or more observations have the same value (tied observations), they are given the average of the ranks they would have if no ties had occurred.

MANN-WHITNEY "U" TEST

This is the equivalent of the "t" test for two independent samples. The observations of both groups are combined and ranked, considering their algebraic size. If the two samples come from populations A and B, H_0 : the two groups have the same distribution

H_1 : a - the population A is larger than population B (regardless of their shape (or $B > A$) one tailed test

b - A is different from B two-tailed test

If n_1 is the size of the smaller sample and n_2 the size of the larger one, R_1 and R_2 the corresponding sums of the ranks of the respective groups, the test statistic is :

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

$$\text{or } U' = n_1 n_2 - U$$

The smaller of these two values is the test statistic, whose sampling distribution is known and found in tables (*)

(*) for example in S.SIEGEL

STAT.17

When n_2 is larger than 20, the statistic :

$$z = \frac{U - (n_1 n_2 / 2)}{\sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}}$$

is normally distributed with zero mean and unit variance. The program computes the values of U and (when n_2 is larger than 20) of z and $P(z)$.

WILCOXON MATCHED-PAIRS SIGNED RANKS TEST

This is the equivalent of the "t" test for related samples. The differences d_i between each pair of observations are ranked without regard to their sign. Then the sign of the difference is affixed to each rank. The ranks having a + sign are summed and the ranks having a - sign are summed. The statistic "T" is the smaller of these two sums. When a difference d is equal to zero, this pair of observations is dropped from the analysis. When two or more ranks are tied, they are given the average of the sum of their ranks.

If H_0 (the sum of the d 's is equal to zero) is true, we would expect the two sums to be about equal. The distribution of "T" is given in tables. When N , the number of paired observations is larger than 25, the statistic

$$z = \frac{T - N(N - 1)/4}{\sqrt{\frac{N(N + 1)(2N + 1)}{24}}}$$

is normally distributed with zero mean and unit variance.

The program computes the values of "T" and (when N is larger than 25) of z and $P(z)$.

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE

This is the equivalent of the single classification ANOVA. The observations or scores of the a samples are combined and ranked, and the sum of the ranks R_j of each sample (column) is computed. The statistic :

$$H = \frac{12}{N(N + 1)} \sum \frac{R_j^2}{n_j} - 3(N - 1)$$

is approximately distributed as a chi-square with $(a - 1)$ degrees of freedom.

H_0 : the a samples come from the same population or from populations with the same average.

STAT.17

The program computes "H" and $P(H)$. If this probability is smaller than the significance level, H_0 can be rejected.

FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE

This is the equivalent of the randomized complete blocks ANOVA. With an experiment with a columns and b rows (blocks), the observations are ranked in each block. Then, the ranks of each column are summed (R_j). The statistic :

$$X_r^2 = \frac{12}{ba(a+1)} \sum (R_j)^2 - 3b(a+1)$$

has approximately a chi square distribution with $(a - 1)$ degrees of freedom. The program computes X_r^2 and its probability. If P is smaller than the significance level, H_0 (the mean ranks of the columns are equal) can be rejected.

USER INSTRUCTIONS I.

 PROGRAMMABLAUF II
 INSTRUCTIONS D'EMPLOI II
 NORME OPERATIVE II

STAT.17

Step Schnitt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in program STAT.17, tracks 1 to 6			
2	Initialize		XEQ "RANG"	
	<u>MANN-WHITNEY</u>			
3	Call		A	
4	Enter : nber of groups	2	R/S	
5	Input the ranks of the 1st group	$x_1 \dots$	R/S	
6	After the last rank, call display of : rank total n		B	R n
	<u>Correction routine</u>			
7	Call		E	
	input the erroneous rank	x_E	R/S	
	then the correct one	x_C	R/S	
8	For the second group, repeat steps 5 and 6			
9	Display : "U" if $n_2 > 20$ z P(z)			U z P
10	For another set of data, return to step 3			
	<u>WILCOXON</u>			
11	Call		D	
12	Input the positive ranks	$+ x_i \dots$	R/S	
13	Call		B	
	Display : rank total n			R n
14	Input the negative ranks	$- x_i \dots$	R/S	
15	Call		B	
	Display : R n statistic "T" z P(z) one-tailed P(z) two-tailed			R n T z P.UNI P.BIL.
16	For another set of data, return to step 11			
	<u>KRUSKAL-WALLIS</u>			
17	Call		A	
18	Enter : nber of groups	a	R/S	
19	Input ranks of 1st group	$x_i \dots$	R/S	
20	After the last rank, call Display : rank total n		B	R n
21	Repeat steps 19 and 20 for the other groups			

5

PROGRAMMABLAUF II
INSTRUCTIONS D'EMPLOI II
NORME OPERATIVE II

Step Schnitt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
22	<u>Correction routine</u> see step 7			
23	After the last group, display : statistic "H" P(H)			H P
24	For another set of data, return to step 17			
	<u>FRIEDMAN</u>			
25	Call		C	
26	Enter : nber columns nber rows	a b	R/S R/S	
27	Input ranks of the first column	$x_i \dots$	R/S	
28	Call Display : rank total n		B	R n
29	For the other groups, repeat steps 27 and 28			
30	<u>Correction routine</u> see step 7			
31	After the last group, display : χ^2_r $P(\chi^2_r)$			χ^2 P
32	For another set of data, return to step 25			

Significance testing.

The F values are computed differently, according to the type of ANOVA

Model I ANOVA : A/Error, B/Error, AxB/Error

if the interaction AxB is significant, the two factors are not independent, and the program does not compute F_A and F_B

Model II ANOVA : AxB /Error. If AxB is significant, A/AxB and B/AxB

If AxB is not significant, it can be pooled with E :

A/Pooled and B/Pooled

Mixed Model ANOVA : A/AxB (or A/Pooled); B/Error

The data are input by groups of n items and by row. The program displays the total of each group T_g and the total of the row T_b ; when all the data are entered, display of the column totals, T_a . The sums of squares are :

$$\text{Total sum of squares} : \sum y^2 - \text{C.F.} \quad (1)$$

$$\text{C.F.} = (\sum y)^2 / abn$$

$$\text{Group S.S.} : \sum T_g^2 / n - \text{C.F.} \quad (2)$$

$$\text{Factor A S.S.} : \sum T_a^2 / bn - \text{C.F.} \quad (3)$$

$$\text{Factor B S.S.} : \sum T_b^2 / an - \text{C.F.} \quad (4)$$

$$\text{Interaction AxB S.S.} : (2) - (3) - (4)$$

$$\text{Error} : (1) - (2)$$

STAT.17

EXAMPLE 1 - MANN-WHITNEY (*)Small sample

XEQ "RANG"
2,00 RUN

7,00 RUN
4,00 RUN
6,00 RUN
1,00 RUN
8,00 RUN
XEQ B

R=26,00
n=5,00

9,00 RUN
5,00 RUN
3,00 RUN
2,00 RUN
XEQ B

R=19,00
n=4,00

U=9,00

Large sample

XEQ A
2,00 RUN

29,50 RUN
24,50 RUN
24,50 RUN
16,00 RUN
16,00 RUN
16,00 RUN
12,00 RUN
9,50 RUN
9,50 RUN
5,00 RUN
5,00 RUN
5,00 RUN
5,00 RUN
5,00 RUN
1,50 RUN
XEQ B

R=200,00
n=16,00

39,00 RUN
38,00 RUN
36,00 RUN
36,00 RUN
36,00 RUN
33,00 RUN
33,00 RUN
33,00 RUN
29,50 RUN
29,50 RUN
29,50 RUN
24,50 RUN
24,50 RUN
24,50 RUN
24,50 RUN
20,50 RUN
20,50 RUN
16,00 RUN
16,00 RUN
16,00 RUN
9,50 RUN
9,50 RUN
1,50 RUN
XEQ B

R=580,00
n=23,00

U=64,00
z=3,43
P.UNI=4,63E-4
P.BIL=9,27E-4

STAT.17

EXAMPLE 2 - WILCOXON (≡)

Small sample

XEQ D
 7.00 RUN
 8.00 RUN
 4.00 RUN
 5.00 RUN
 6.00 RUN
 2.00 RUN
 XEQ B
 R=32.00
 n=6.00

-1.00 RUN
 -3.00 RUN
 XEQ B
 R=-4.00
 n=2.00
 T=-4.00

Large sample

XEQ D
 4.50 RUN
 20.00 RUN
 20.00 RUN
 4.50 RUN
 4.50 RUN
 23.00 RUN
 16.50 RUN
 23.00 RUN
 16.50 RUN
 4.50 RUN
 23.00 RUN
 25.50 RUN
 11.50 RUN
 11.50 RUN
 11.50 RUN
 4.50 RUN
 20.00 RUN
 25.50 RUN
 11.50 RUN
 16.50 RUN
 XEQ B

R=298.00
 n=20.00

-11.50 RUN
 -4.50 RUN
 -4.50 RUN
 -16.50 RUN
 -11.50 RUN
 -4.50 RUN
 XEQ B

R=-53.00
 n=6.00

T=-53.00
 z=3.11
 P.UNI=1.15E-3
 P.BIL=2.30E-3

(≡) S.SIEGEL pp. 79 and 82

STAT.17

EXAMPLE 3 - KRUSKAL-WALLIS

(※)

XEQ A

3,00 RUN

14,00 RUN

5,00 RUN

4,00 RUN

10,00 RUN

3,00 RUN

1,00 RUN

6,00 RUN

2,00 RUN

XEQ B

R=45,00

n=8,00

15,00 RUN

8,00 RUN

11,00 RUN

12,00 RUN

18,00 RUN

7,00 RUN

XEQ B

R=71,00

n=6,00

9,00 RUN

16,00 RUN

13,00 RUN

17,00 RUN

XEQ B

R=55,00

n=4,00

H=7,90

P=0,019

(※) Data of example 1, Program STAT.05 - The observations have been ranked.

STAT.17

EXAMPLE 4 - FRIEDMAN

(≡)

XEQ C
3,00 RUN
18,00 RUN

1,00 RUN
2,00 RUN
1,00 RUN
1,00 RUN
3,00 RUN
2,00 RUN
3,00 RUN
1,00 RUN
3,00 RUN
3,00 RUN
2,00 RUN
2,00 RUN
3,00 RUN
2,00 RUN
2,00 RUN
2,50 RUN
3,00 RUN
3,00 RUN
2,00 RUN

XEQ B

R=39,50
n=18,00

3,00 RUN
3,00 RUN
3,00 RUN
2,00 RUN
1,00 RUN
3,00 RUN
2,00 RUN
3,00 RUN
1,00 RUN
1,00 RUN
3,00 RUN
3,00 RUN
2,00 RUN
3,00 RUN
2,50 RUN
2,00 RUN
2,00 RUN
3,00 RUN

XEQ B

R=42,50
n=18,00

2,00 RUN
1,00 RUN
2,00 RUN
3,00 RUN
2,00 RUN
1,00 RUN
1,00 RUN
2,00 RUN
2,00 RUN
2,00 RUN
1,00 RUN
1,00 RUN
1,00 RUN
1,00 RUN
1,00 RUN
1,00 RUN
1,00 RUN
1,00 RUN

XEQ B

R=26,00
n=18,00

X2=8,58
P=0,014

(≡) S.SIEGEL p.171

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.17

01*LBL "RANG"	58 RCL 26	115 RCL 26	172 1	229 +
02*LBL A	59 -	116 RCL 26	173 +	230 *
03 CLRG	60 CHS	117 1	174 *	231 24
04 XEQ 22	61 RCL 27	118 +	175 -	232 /
05 STOP	62 X>Y?	119 *	176 *X2"	233 SQRT
06 STO 20	63 X<>Y	120 /	177 XEQ 11	234 /
07*LBL 01	64 STO 27	121 RCL 27	178 STO 22	235 XEQ 23
08 ADV	65 "U"	122 *	179 RCL 20	236 RTN
09*LBL 02	66 XEQ 11	123 3	180 1	237*LBL 22
10 STOP	67 RCL 11	124 RCL 26	181 -	238 1
11 ST+ 21	68 RCL 12	125 1	182 STO 20	239 STO 22
12 7ISZ	69 X<=Y?	126 +	183 XEQ 14	240 11
13 GTO 02	70 X<>Y	127 *	184 CF 00	241 STO 23
14*LBL B	71 20	128 -	185 RTN	242 RTN
15 RCL 21	72 X>Y?	129 "H"	186*LBL D	243*LBL 23
16 "R"	73 RTN	130 XEQ 11	187 CLRG	244 ABS
17 XEQ 11	74 RCL 27	131 STO 22	188 XEQ 22	245 SF 13
18 STO IND 22	75 RCL 11	132 RCL 20	189 SF 01	246 "Z"
19 RCL 25	76 RCL 12	133 1	190 2	247 XEQ 11
20 SF 13	77 *	134 -	191 STO 20	248 CF 13
21 "N"	78 2	135 STO 20	192 GTO 01	249 STO 21
22 XEQ 11	79 /	136 XEQ 14	193*LBL 20	250 XEQ 12
23 CF 13	80 -	137 RTN	194 CF 01	251 "P.UNI"
24 ADV	81 RCL 11	138*LBL C	195 RCL 11	252 XEQ 11
25 STO IND 23	82 RCL 12	139 CLRG	196 RCL 12	253 2
26 0	83 *	140 XEQ 22	197 +	254 *
27 STO 21	84 RCL 11	141 SF 00	198 STO 20	255 "P.BIL"
28 STO 25	85 RCL 12	142 STOP	199 RCL 01	256 XEQ 11
29 1	86 +	143 STO 20	200 RCL 02	257 RTN
30 ST+ 24	87 1	144 STOP	201 X>Y?	258 2
31 ST+ 22	88 +	145 STO 20	202 X<>Y	259*LBL 14
32 ST+ 23	89 *	146 GTO 01	203 "T"	260 RCL 22
33 RCL 20	90 12	147*LBL 18	204 XEQ 11	261 SQRT
34 RCL 24	91 /	148 RCL IND 22	205 STO 27	262 STO 21
35 X>Y?	92 SQRT	149 X=0?	206 RCL 28	263 RCL 20
36 GTO 02	93 /	150 GTO 19	207 25	264 1
37 2	94 XEQ 23	151 X+2	208 X>Y?	265 X=Y?
38 RCL 20	95 RTN	152 ST+ 27	209 RTN	266 GTO 16
39 X>Y?	96*LBL 03	153 1	210 RCL 27	267 RCL 20
40 GTO 03	97 XEQ 22	154 ST+ 22	211 ABS	268 2
41 RCL 11	98 FS? 00	155 GTO 18	212 RCL 28	269 X=Y?
42 FS? 01	99 GTO 18	156*LBL 19	213 RCL 28	270 GTO 17
43 GTO 20	100*LBL 04	157 12	214 1	271 RCL 20
44 RCL 12	101 RCL IND 22	158 RCL 28	215 +	272 2
45 *	102 X=0?	159 RCL 20	216 *	273 /
46 STO 26	103 GTO 05	160 *	217 4	274 INT
47 RCL 11	104 X+2	161 RCL 20	218 /	275 LASTX
48 RCL 11	105 RCL IND 23	162 1	219 -	276 X>Y?
49 1	106 ST+ 26	163 +	220 RCL 28	277 GTO 06
50 +	107 /	164 *	221 RCL 28	278 SF 01
51 *	108 ST+ 27	165 /	222 1	279 RCL 20
52 2	109 1	166 RCL 27	223 +	280 2
53 /	110 ST+ 22	167 *	224 *	281 -
54 +	111 ST+ 23	168 3	225 RCL 28	282 2
55 RCL 01	112 GTO 04	169 RCL 28	226 2	283 /
56 -	113*LBL 05	170 *	227 *	284 STO 25
57 STO 27	114 12	171 RCL 20	228 1	285 XEQ 13

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.17

286 0	343 RCL 21	400 *
287 STO 05	344 STO 06	401 GTO 10
288 1	345 GTO 08	402*LBL 17
289 STO 06	346*LBL 13	403 XEQ 13
290*LBL 08	347 PI	404 RCL 01
291 RCL 22	348 2	405 RCL 02
292 *	349 *	406 *
293 RCL 05	350 SQRT	407 GTO 10
294 2	351 STO 01	408*LBL 11
295 +	352 RCL 22	409 "I="
296 STO 05	353 2	410 ARCL X
297 /	354 /	411 AVIEW
298 ST+ 06	355 CHS	412 RTN
299 7DSZ	356 ETX	413*LBL E
300 GTO 08	357 RCL 01	414 STOP
301 FS? 01	358 1/X	415 ST- 21
302 GTO 09	359 *	416 7DSZ
303 RCL 07	360 STO 02	417 GTO 02
304 2	361 RTN	418 RTN
305 *	362*LBL 12	419 .END.
306 RCL 02	363 1	
307 2	364 RCL 21	
308 *	365 ,196854	
309 RCL 06	366 *	
310 *	367 +	
311 +	368 RCL 21	
312*LBL 10	369 X+2	
313 FIX 3	370 ,115194	
314 "P"	371 *	
315 XEQ 11	372 +	
316 FIX 2	373 RCL 21	
317 RTN	374 3	
318*LBL 09	375 Y+X	
319 RCL 01	376 ,000344	
320 RCL 02	377 *	
321 RCL 06	378 +	
322 *	379 RCL 21	
323 *	380 4	
324 FIX 3	381 Y+X	
325 "P"	382 ,019527	
326 XEQ 11	383 *	
327 FIX 2	384 +	
328 CF 01	385 -4	
329 RTN	386 Y+X	
330*LBL 06	387 2	
331 RCL 20	388 /	
332 1	389 CHS	
333 -	390 1	
334 2	391 +	
335 /	392 1	
336 1	393 X<>Y	
337 -	394 -	
338 STO 25	395 STO 07	
339 XEQ 12	396 RTN	
340 XEQ 13	397*LBL 16	
341 1	398 XEQ 12	
342 STO 05	399 2	

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

STAT.17

Registers Datenspeicher Registres de données Registri				Status Betriebsart Modes opératoires Modi operativi			
00		50		Size <u>030</u>	Total Reg. <u>177</u>	User Mode	
	1 to 10			Eng ☐	Fix ☒	Sci ☐	On ☒
	R _j			Deg ☐	Rad ☐	Grad ☐	Off ☐
05		55		Purpose Bedeutung Signification Scopo Flags SET CLEAR			
				00	Friedman	☒	
				01	Wilcoxon	☒	
				02			
10		60		03			
	11 to 19			04			
	n			05			
				06			
				07			
15		65		08			
				09			
				10			
				11	Audio execute		
				12			
20		70		13			
	a			14			
				15			
				16			
				17			
25		75		18			
				19			
	U; R ² /n			20			
				21	Printer Enable		
				22	Number Input		
30		80		23	Alpha Input		
				24	Range Ignore		
				25	Error Ignore		
				26	Audio Enable		
				27	User Mode		
35		85		28	Decimal Point		
				29	Digit Grouping		
				Assignments Tastenbelegung/Assignations/Assegnamenti			
40		90		Function	Key	Function	Key
				Funktion	Taste	Funktion	Taste
				Fonction	Touche	Fonction	Touche
				Funzione	Tasto	Funzione	Tasto
45		95					
		99					

NON PARAMETRIC TESTSANALYSIS OF FREQUENCIESDESCRIPTION

When a variable, instead of being measured, is qualitative, and distributed into two or more classes depending on some criterion, the tests are performed on frequencies. They are based on a comparison between the frequencies actually observed and the theoretical frequencies (expected) that we should have if a null hypothesis H_0 was verified.

I - Tests of goodness of fit

When a set of frequencies f_o , distributed in k classes, is compared with the corresponding theoretical frequencies f_t calculated under the hypothesis H_0 (for instance, the sample is drawn from a normal, or binomial, ..., population), a statistic is calculated, having approximately the sampling distribution of chi-square.

a - Pearson χ^2 test

The statistic $\chi^2 = \sum \frac{(f_o - f_t)^2}{f_t}$ has a chi-square distribution

with n' degrees of freedom; the expected frequency f_t in any class should be at least 5.

b - Maximum likelihood or G test

The statistic $G = 2 \left(\sum f_o \ln f_o - \sum f_o \ln f_t \right)$ has a chi-square distribution with n' d.f. This test is less sensitive to low theoretical frequencies, and, with a calculator, is even simpler than the first one. The number of d.f. may vary, according to the number of parameters estimated from the data; when no value was computed (hypothesis extrinsic to the data) $n' = (k - 1)$; when 2 values were computed (for instance mean and variance), $n' = (k - 3)$.

The program uses the maximum likelihood approximation.

II - Tests of independence

Used to study if two variables are associated. In a random sample of size n , each observation may be cross-classified according to two criteria, so that it belongs to one and only one level of each criterion. The data are displayed in a contingency table.

Second criterion Levels	First criterion Levels				Total
	1	2	3..... c		
1	.	.	.	.	.
2	.	.	.	.	.
3	.	.	.	.	.
⋮					
r	.	.	.	.	.
Total	.	.	.	.	N

Such a table is called an $(r \times c)$ table, with r rows and c columns.

1 - (2 x 2) Table

The simplest case is when the two criteria have two levels, leading to a (2×2) contingency table like the following one :

	Treatments		Totals
	1	2	
Group I	A	B	(A + B)
Group II	C	D	(C + D)
Totals	(A + C)	(B + D)	N

Conventionally, the frequencies in the four cells are called A, B, C, D and the marginal totals (A + B)

The hypothesis H_0 to be tested is that the two criteria are independent.

a - Fisher exact test

When the total number of observations is small ($N < 25$), or when the expected frequency in a cell f_t is less than 5, the Fisher exact test should be used. It is based on the hypergeometric distribution, the marginal totals being considered as fixed. The exact probability of observing a particular set of frequencies is given by :

$$p = \frac{(A+B)! (C+D)! (A+C)! (B+D)!}{N! A! B! C! D!}$$

the sign ! stands for "factorial".

STAT.18

The probability under H_0 of the test is the sum P of the probabilities p of observing the actual data, and even more extreme sets (i.e. all the combinations of frequencies in the four cells, the marginal totals being fixed, until the frequency in a cell is zero).

The program gives the exact probability for a one-tailed and a two-tailed test.

b - Pearson X^2 test

When N is larger than 20, the classical test is the X^2 corrected for continuity (Yates correction). The statistic

$$X^2 = \frac{N(|AD - BC| - N/2)^2}{(A+B)(C+D)(A+C)(B+D)}$$

has a chi-square distribution with 1 degree of freedom

2 - (r x c) tables

For a contingency table with r rows and c columns, the program provides a G test based on the formula :

$$G = 2 \left[\left(\sum f_o \ln f_o \right) - \left(\sum T_c \ln T_c \right) - \left(\sum T_r \ln T_r \right) + N \ln N \right]$$

where f_o are the frequencies in each cell, T_c and T_r the marginal totals.

G has a chi-square distribution with $(r-1)(c-1)$ degrees of freedom.

H_0 being : "the rows and columns are independant", if $P(G)$ is lower

than the significance level α , H_0 can be rejected.

**PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I**

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.10, tracks 1 to 7			
2	Initialize			
3	Enter : levels of Factor A levels of Factor B number of replicates	a b n	XEQ"ANVA.6" R/S R/S R/S	
4	Input : data of the first group of the first row			
5	Call Display of group total T_g	$y_i \dots$	R/S B	
6	Repeat steps 4 and 5 for the other groups			Σ
7	At the end of the row, display of the row total T_r			
8	Repeat steps 4 to 7 for the other rows			ΣB
9	At the end of the last row, display of the column totals T_a			ΣA
10	<u>Correction routine</u> Call input the erroneous data then the correct one	y_E y_C	E R/S R/S	
11	Display of : - Model I ANOVA Call - Model II ANOVA Call - Mixed Model ANOVA Call		A C D	ANVA
12	For another set of data, call and return to step 3		F	

STAT.18

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.18, tracks 1 to 7			
2	Initialize		XEQ"FREQ"	
	<u>1 - Test of Goodness of fit</u>			
3	Call		A	
4	Input the data by pairs observed frequency	f_o	R/S	
	theoretical frequency	f_t	R/S	
5	After the last pair, call		B	
6	Input : number of d.f.	d.f.	R/S	
	Display : G			G
	P(G)			P
7	If $P(G) < \alpha$, H_0 is rejected For another set of data, return to step 3			
	<u>2 - Table (2 x 2)</u>			
8	Call		C	
9	Input the frequencies	A	R/S	
		B	R/S	
		C	R/S	
		D	R/S	
	Display			(A+B)
				(C+D)
				(A+C)
				(B+D)
	<u>a - Fisher exact test</u>			
10	Call		D	
	Display : prob. one-tailed test			P.UNI
	prob. two-tailed test			P.BIL
	<u>b - χ^2 test</u>			
11	Call		F	
12	Display of : calculated χ^2			χ^2
	prob. χ^2			P
	If $P(\chi^2) < \alpha$, H_0 is rejected			
13	For another set of data, return to step 8.			
	<u>3-Table (r x c) (c ≤ 12)</u>			
14	Call		G	
15	Enter : number of columns	c	R/S	
	number of rows	r	R/S	
16	Input the frequencies of the first row	f	R/S	

67

PROGRAMMABLAUF II
INSTRUCTIONS D'EMPLOI II
NORME OPERATIVE II

Step Schnitt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
17	After the last one, call Display of : row total T_r		H	ΣR
18	<u>Correction routine</u> After entering a wrong f , call input the erroneous frequency then the correct one	f_E f_G	E R/S R/S	
19	Repeat steps 16 and 17 for the other rows			
20	After the last row, Display of : the column totals T_c the grand total G number of d.f. $P(G)$			ΣC N G D.L. P
21	If $P(G) < \alpha$, H_0 is rejected For another set of data, return to step 14			

EXAMPLE 1 - Goodness of fit

Number of boys in 2 000 families of four children. Does it fit the H_0 hypothesis : binomial distribution with $p = 0,50$

	0	1	2	3	4
f_o	118	485	750	515	132
f_t	125	500	750	500	125

XEQ A

118,000 RUN

125,000 RUN

485,000 RUN

500,000 RUN

750,000 RUN

750,000 RUN

515,000 RUN

500,000 RUN

132,000 RUN

125,000 RUN

XEQ B

G=1,685

4,000 RUN

P=0,794

EXAMPLE 2 - Table (2 x 2) Fisher exact test (≡)

XEQ "FREQ"

XEQ C

1,00 RUN

6,00 RUN

4,00 RUN

1,00 RUN

A+B=7,00

C+D=5,00

A+C=5,00

B+D=7,00

N=12,00

XEQ D

P.UNI=0,0455

P.BIL=0,0909

(≡) SIEGEL p.98

EXAMPLE 3 - Table (2 x 2) χ^2 test (*)

XEQ C
90.00 RUN
10.00 RUN
97.00 RUN
3.00 RUN

A+B=100.00
C+D=100.00
A+C=187.00
B+D=13.00
N=200.00

XEQ F

$\chi^2=2.96$
P=0.085

EXAMPLE 4 - Table (r x c) (**)

XEQ G
4.00 RUN
3.00 RUN

(error) 120.00 RUN
157.00 RUN
XEQ e
157.00 RUN
57.00 RUN
10.00 RUN
5.00 RUN
XEQ H

 $\Sigma R=200.00$

125.00 RUN
53.00 RUN
10.00 RUN
4.00 RUN
XEQ H

 $\Sigma R=200.00$ $\Sigma C=365.00$ $\Sigma C=169.00$ $\Sigma C=50.00$ $\Sigma C=16.00$

N=600.00

G=7.17

D.L.=6.00

P=0.306

112.00 RUN
59.00 RUN
22.00 RUN
7.00 RUN
XEQ H

 $\Sigma R=200.00$

(*) PHILIPPE p.47

(**) PHILIPPE p.44

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.18

01*LBL "FREQ"	58 RCL 30	115 XEQ 11	172 /	229 FS? 01
02*LBL A	59 RCL 32	116 2	173 RCL 36	230 GTO 06
03 CLRG	60 +	117 *	174 /	231 RCL 07
04*LBL 01	61 STO 37	118 "P.BIL"	175 RCL 37	232 2
05 STOP	62 "A+C"	119 XEQ 11	176 /	233 *
06 STO 20	63 XEQ 11	120 FIX 2	177 RCL 39	234 RCL 02
07 LN	64 RCL 31	121 RTN	178 /	235 2
08 RCL 20	65 RCL 33	122*LBL 05	179 ADV.	236 *
09 *	66 +	123 30	180 "X2"	237 RCL 06
10 ST+ 00	67 STO 36	124 STO 25	181 XEQ 11	238 *
11 STOP	68 "B+D"	125 RCL IND 25	182 STO 24	239 +
12 LN	69 XEQ 11	126 FACT	183 1	240 FIX 3
13 RCL 20	70 RCL 34	127 STO 12	184 STO 22	241 "P"
14 *	71 "N"	128*LBL 16	185 XEQ 10	242 XEQ 11
15 ST+ 01	72 XEQ 11	129 71SZ	186 RTN	243 FIX 2
16 ADV	73 RTN	130 RCL IND 25	187*LBL 10	244 RTN
17 GTO 01	74*LBL D	131 FACT	188 RCL 24	245*LBL 06
18*LBL B	75 XEQ 05	132 ST* 12	189 SORT	246 RCL 10
19 RCL 00	76 RCL 30	133 34	190 STO 26	247 RCL 02
20 RCL 01	77 X=0?	134 RCL 25	191 RCL 22	248 RCL 06
21 -	78 GTO 12	135 X*Y?	192 1	249 *
22 2	79 RCL 31	136 GTO 16	193 X=Y?	250 *
23 *	80 X=0?	137 71SZ	194 GTO 08	251*LBL 09
24 "G"	81 GTO 12	138 RCL IND 25	195 RCL 22	252 FIX 3
25 XEQ 11	82 RCL 32	139 FACT	196 2	253 "P"
26 STO 24	83 X=0?	140 STO 13	197 X=Y?	254 XEQ 11
27 STOP	84 GTO 12	141*LBL 13	198 GTO 17	255 FIX 2
28 STO 22	85 RCL 33	142 71SZ	199 RCL 22	256 CF 01
29 XEQ 10	86 X=0?	143 RCL IND 25	200 2	257 RTN
30 RTN	87 GTO 12	144 FACT	201 /	258*LBL 07
31*LBL C	88 RCL 30	145 ST* 13	202 INT	259 RCL 22
32 CLRG	89 RCL 33	146 38	203 LASTX	260 1
33 STOP	90 *	147 RCL 25	204 X*Y?	261 -
34 STO 30	91 RCL 31	148 X*Y?	205 GTO 07	262 2
35 STOP	92 RCL 32	149 GTO 13	206 SF 01	263 /
36 STO 31	93 *	150 RCL 13	207 RCL 22	264 1
37 STOP	94 -	151 RCL 12	208 2	265 -
38 STO 32	95 X<0?	152 /	209 -	266 STO 25
39 STOP	96 GTO 14	153 ST+ 14	210 2	267 XEQ 04
40 STO 33	97 1	154 RTN	211 /	268 XEQ 02
41 +	98 ST+ 30	155*LBL F	212 STO 25	269 1
42 +	99 ST+ 33	156 RCL 34	213 XEQ 02	270 STO 05
43 +	100 ST- 31	157 RCL 30	214 0	271 RCL 26
44 STO 34	101 ST- 32	158 RCL 33	215 STO 05	272 STO 06
45 RCL 30	102 GTO 15	159 *	216 1	273 GTO 03
46 RCL 31	103*LBL 14	160 RCL 31	217 STO 06	274*LBL 02
47 +	104 1	161 RCL 32	218*LBL 03	275 PI
48 STO 35	105 ST- 30	162 *	219 RCL 24	276 2
49 ADV	106 ST- 33	163 -	220 *	277 *
50 "A+B"	107 ST+ 31	164 ABS	221 RCL 05	278 SORT
51 XEQ 11	108 ST+ 32	165 RCL 34	222 2	279 STO 10
52 RCL 32	109*LBL 15	166 2	223 +	280 RCL 24
53 RCL 33	110 XEQ 05	167 /	224 STO 05	281 2
54 +	111*LBL 12	168 -	225 /	282 /
55 STO 36	112 RCL 14	169 X+2	226 ST+ 06	283 CHS
56 "C+D"	113 FIX 4	170 *	227 7DSZ	284 ETX
57 XEQ 11	114 "P.UNI"	171 RCL 35	228 GTO 03	285 RCL 10

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

286 1/X	343 STOP	400 *
287 *	344 STO 23	401 "G"
288 STO 02	345 13	402 XEQ 11
289 RTN	346 X<=Y?	403 STO 24
290+LBL 04	347 GTO 19	404 RCL 23
291 1	348 STOP	405 1
292 RCL 26	349 STO 21	406 -
293 .196854	350 ADV	407 RCL 21
294 *	351 ADV	408 1
295 +	352+LBL 20	409 -
296 RCL 26	353 STOP	410 *
297 X+2	354 X*0?	411 STO 22
298 .115194	355 SF 02	412 "D.L."
299 *	356 ST+ 13	413 XEQ 11
300 +	357 ST+ IND 25	414 XEQ 10
301 RCL 26	358 7ISZ	415 RTN
302 3	359 XEQ 21	416+LBL 21
303 Y+X	360 GTO 20	417 FS?C 02
304 .000344	361+LBL H	418 LN
305 *	362 RCL 13	419 LASTX
306 +	363 "SR"	420 *
307 RCL 26	364 XEQ 11	421 ST+ 16
308 4	365 ADV	422 RTN
309 Y+X	366 ST+ 14	423+LBL 22
310 .019527	367 XEQ 22	424 LN
311 *	368 0	425 LASTX
312 +	369 STO 13	426 *
313 -4	370 STO 25	427 ST+ 17
314 Y+X	371 1	428 RTN
315 2	372 ST+ 15	429+LBL E
316 /	373 RCL 21	430 7DSZ
317 CHS	374 RCL 15	431 STOP
318 1	375 X*Y?	432 X*0?
319 +	376 GTO 20	433 SF 02
320 1	377+LBL 23	434 ST- 13
321 X<Y	378 RCL IND 25	435 ST- IND 25
322 -	379 "C"	436 FS?C 02
323 STO 07	380 XEQ 11	437 LN
324 RTN	381 XEQ 22	438 LASTX
325+LBL 00	382 7ISZ	439 *
326 XEQ 04	383 RCL 23	440 ST- 16
327 2	384 RCL 25	441 GTO 20
328 *	385 X*Y?	442 .END.
329 GTO 09	386 GTO 23	
330+LBL 17	387 RCL 14	
331 XEQ 02	388 ADV	
332 RCL 10	389 "N"	
333 RCL 02	390 XEQ 11	
334 *	391 ADV	
335 GTO 09	392 LN	
336+LBL 11	393 LASTX	
337 "I="	394 *	
338 ARCL X	395 RCL 16	
339 AVIEW	396 +	
340 RTN	397 RCL 17	
341+LBL G	398 -	
342 CLRG	399 2	

STAT.18

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN

REGISTRES, INDICATEURS, MODES OPÉRATOIRES

REGISTRI, MODI OPERATIVI, FLAGS

Registers Datenspeicher Registres de données Registri				Status Betriebsart Modes opératoires Modi operativi			
00	foLNfo	50		Size	040	Total Reg.	
	foLNft			Eng	☐	Fix	☒
	Sum col.			Deg	☐	Rad	☐
	.			Sci	☐	Grad	☐
	.			User Mode			
05	.	55		On	☒	Off	☐
	.			Purpose Bedeutung Signification Scopo			
	.			Flags SET CLEAR			
	.			00			
	.			01	P(X^2) routine	☒	
	.			02	f = 0	☒	
10	.	60		03			
	.			04			
	.			05			
	.			06			
	.			07			
15		65		08			
				09			
				10			
				11	Audio execute		
				12			
20	fo	70		13			
				14			
	d.f.			15			
	G			16			
				17			
25		75		18			
				19			
				20			
				21	Printer Enable		
				22	Number Input		
30	A	80		23	Alpha Input		
	B			24	Range Ignore		
	C			25	Error Ignore		
	D			26	Audio Enable		
	N			27	User Mode		
35	A+B	85		28	Decimal Point		
	C+D			29	Digit Grouping		
	A+C			Assignments Tastenbelegung / Assignations / Assegnamenti			
	B+D			Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto
40		90					
45		95					
		99					

APPLIED STATISTICS II

**TWO-WAY ANOVA
THREE-FACTOR ANOVA
THREE, FOUR AND FIVE FACTORS AT THE LEVELS
CORRELATION COEFFICIENT
LINEAR REGRESSION
ANALYSIS OF COVARIANCE
NON PARAMETRIC RANK TESTS
NON PARAMETRIC FREQUENCY TESTS**



EXAMPLE 1 - AxB non significant (*)

(same data used for the three Models)

XEQ "ANVA6"		Model	Model	Mixed
2,00	RUN	I	II	Model
2,00	RUN	A	C	D
2,00	RUN			
65,20	RUN			
66,40	RUN			
	XEQ B			
Σ=131,60				
69,50	RUN	FACT.A	FACT.A	FACT.A
70,50	RUN	D.L.=1,000	D.L.=1,000	D.L.=1,000
	XEQ B	S.C.=40,500	S.C.=40,500	S.C.=40,500
Σ=140,00		C.M.=40,500	C.M.=40,500	C.M.=40,500
Σ.B=271,60		F=64,286	F=75,000	F=75,000
		P=0,002	P=0,001	P=0,001
68,70	RUN	FACT.B	FACT.B	FACT.B
70,10	RUN	D.L.=1,00	D.L.=1,00	D.L.=1,00
	XEQ B	S.C.=30,42	S.C.=30,42	S.C.=30,42
Σ=138,80		C.M.=30,42	C.M.=30,42	C.M.=30,42
73,80	RUN	F=48,29	F=56,33	F=48,29
74,60	RUN	P=0,003	P=0,001	P=0,003
	XEQ B			
Σ=148,40		INT.A*B	INT.A*B	INT.A*B
Σ.B=287,20		D.L.=1,00	D.L.=1,00	D.L.=1,00
		S.C.=0,18	S.C.=0,18	S.C.=0,18
		C.M.=0,18	C.M.=0,18	C.M.=0,18
Σ.A=270,40		F=0,29	F=0,29	F=0,29
Σ.A=288,40		P=0,39	P=0,39	P=0,39
ANVA		ERR.	ERR.	ERR.
		D.L.=4,00	D.L.=4,00	D.L.=4,00
		S.C.=2,52	S.C.=2,52	S.C.=2,52
		C.M.=0,63	C.M.=0,63	C.M.=0,63
		TOT.	TOT.	TOT.
		D.L.=7,00	D.L.=7,00	D.L.=7,00
		S.C.=73,62	S.C.=73,62	S.C.=73,62

(*) PHILIPPE p.197

EXAMPLE 2 - AxB significant (**)

.XEQ "ANVA6"	2.00	RUN	Model I A	Model II C	Mixed Model D
	2.00	RUN			
	3.00	RUN			
	42.40	RUN			
	143.00	RUN			
	42.10	RUN			
		XEQ E			
	143.00	RUN			
	43.00	RUN			
		XEQ B			
$\Sigma=127.50$			FACT.A	FACT.A	FACT.A
			D.L.=1.000	D.L.=1.000	D.L.=1.000
			S.C.=11.603	S.C.=11.603	S.C.=11.603
			C.M.=11.603	C.M.=11.603	C.M.=11.603
	45.30	RUN	FACT.B	F=3.011	F=3.011
	45.10	RUN	D.L.=1.000	P=0.338	P=0.338
	46.40	RUN	S.C.=0.270		
		XEQ B	C.M.=0.270	FACT.B	FACT.B
$\Sigma=136.80$			INT.A*B	D.L.=1.00	D.L.=1.00
			D.L.=1.000	S.C.=0.27	S.C.=0.27
$\Sigma.B=264.30$			S.C.=3.853	C.M.=0.27	C.M.=0.27
			C.M.=3.853	F=0.07	F=0.69
	43.30	RUN	F=9.838	P=0.327	P=0.435
	43.90	RUN	P=0.014		
	44.60	RUN		INT.A*B	INT.A*B
		XEQ B	ERR.	D.L.=1.00	D.L.=1.00
$\Sigma=131.80$			D.L.=8.000	S.C.=3.85	S.C.=3.85
			S.C.=3.133	C.M.=3.85	C.M.=3.85
	44.60	RUN	C.M.=0.392	F=9.84	F=9.84
	44.20	RUN		P=0.01	P=0.01
	45.50	RUN	TOT.		
		XEQ B	D.L.=11.000	ERR.	ERR.
$\Sigma=134.30$			S.C.=18.860	D.L.=8.00	D.L.=8.00
				S.C.=3.13	S.C.=3.13
$\Sigma.B=266.10$				C.M.=0.39	C.M.=0.39
				TOT.	TOT.
$\Sigma.A=259.30$				D.L.=11.00	D.L.=11.00
$\Sigma.A=271.10$				S.C.=18.86	S.C.=18.86
ANVA					

XEQ D

Scan Copyright ©
The Museum of HP Calculators
www.hpmuseum.org

Original content used with permission.

Thank you for supporting the Museum of HP
Calculators by purchasing this Scan!

Please do not make copies of this scan or
make it available on file sharing services.