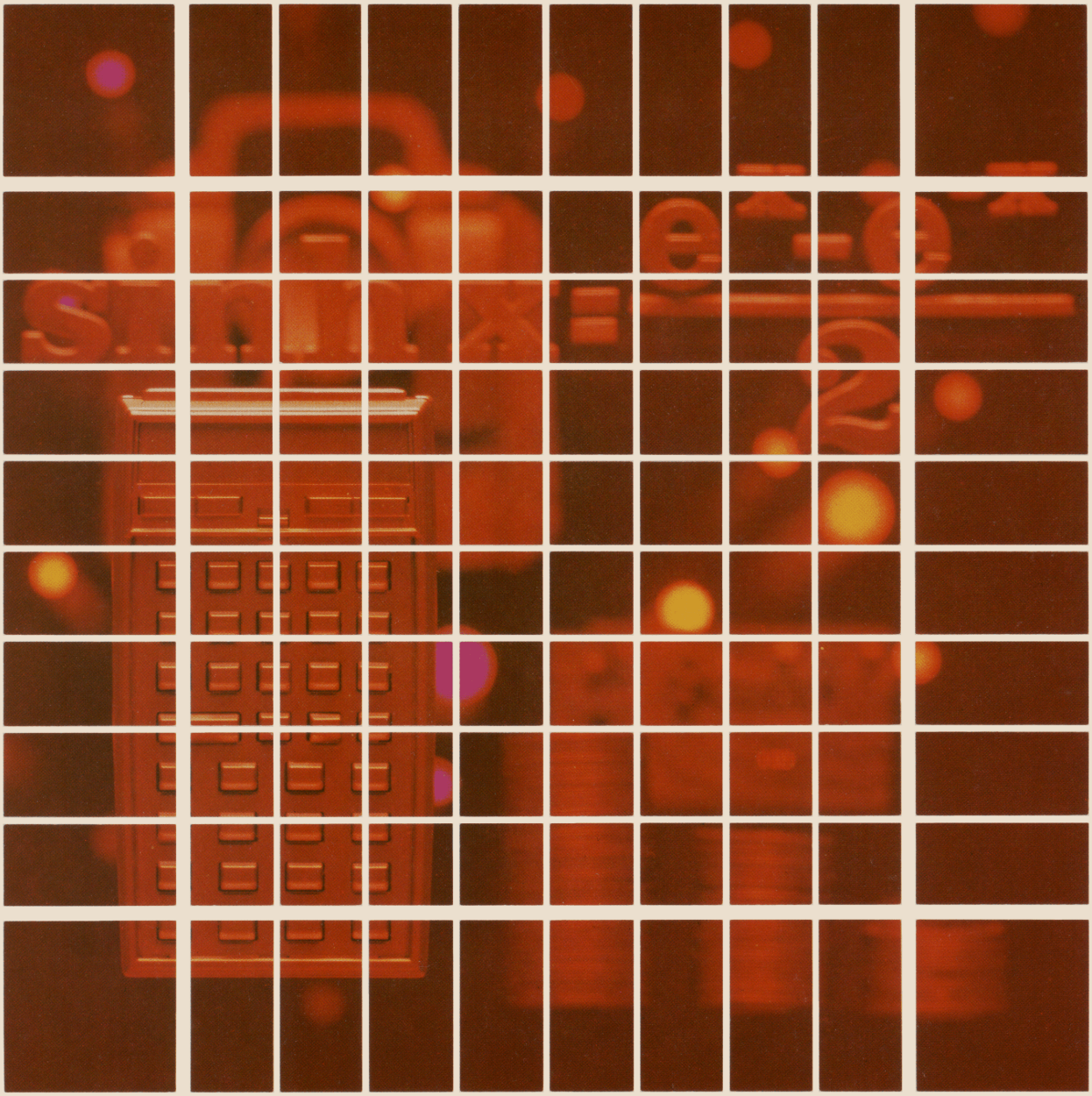
HEWLETT-PACKARD

HP-41C

USER'S LIBRARY SOLUTIONS

Applied statistics II



NOTICE

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 [■] 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 fy 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	Keystrokes	Display
01◆LBL "SAM PLE"	[■] [LBL] [ALPHA] SAMPLE [ALPHA]	*01 LBL"SAMPLE*
02 "THIS IS A "	[ALPHA] *THIS IS A* [ALPHA]	*02"THIS IS A*
03 "⊢SAMPLE "	[ALPHA] [■] [APPEND] SAMPLE	*03" ⊢ SAMPLE*
04 AVIEW	[■] AVIEW [ALPHA]	*04 AVIEW*
05 6	6	*05 6*
06 ENTER↑	[ENTER↑]	*06 ENTER ↑*
07 -2	2 [CHS]	*07 -2*
08 /	[÷]	*08 /*
09 ABS	[XEQ] [ALPHA] ABS [ALPHA]	*09 ABS*
10 STO IND L	[STO] [■] [•] L	*10 STO IND L*
11 "R3="	[ALPHA] R3= [■] [ARCL] 03	*11"R3=*
12 ARCL 03	[■] [AVIEW]	*12 ARCL 03*
13 AVIEW	[ALPHA]	*13 AVIEW*
14 RTN	[■] [RTN]	*14 RTN*

CONTENTS

VOLUME II

STAT.10

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 independant, and can be studied separately.

Factor B (b = 2)	Factor A (a = 3)			
	A_1	A_2	A_3	
B_1	- - } T_g	- -	- -	T_b
B_2	- -	- -	- -	(n = 2)
			T_a	

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

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 independant, 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 :

Total sum of squares : $\Sigma y^2 - C.F$ (1) $\quad C.F. = (\Sigma y)^2/abn$

Group S.S. : $\Sigma T_g^2/n - C.F.$ (2)

Factor A S.S. : $\Sigma T_a^2/bn - C.F.$ (3)

Factor B S.S. : $\Sigma T_b^2/an - C.F.$ (4)

Interaction AxB S.S. : (2) - (3) - (4)

Error : (1) - (2)

USER INSTRUCTIONS I

STAT.10

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		XEQ"ANVA.6"	
3	Enter : levels of Factor A	a	R/S	
	levels of Factor B	b	R/S	
	number of replicates	n	R/S	
4	Input : data of the first group of the first row	y_i.....	R/S	
5	Call		B	
	Display of group total T_g			Σ
6	Repeat steps 4 and 5 for the other groups			
7	At the end of the row, display of the row total T_b			Σ B
8	Repeat steps 4 to 7 for the other rows			
9	At the end of the last row, display of the column totals T_a			Σ A
10	Correction routine			
	Call		E	
	input the erroneous data	y_E	R/S	
	then the correct one	y_C	R/S	
11	Display of :			ANVA
	- Model I ANOVA Call		A	
	- Model II ANOVA Call		C	
	- Mixed Model ANOVA Call		D	
12	For another set of data, call and return to step 3		F	

STAT.10

EXAMPLE 1 - AxB non significant (*)

(same data used for the three Models)

```
                XEQ "ANVA6"
                2,00    RUN
                2,00    RUN
                2,00    RUN

                65,20   RUN
                66,40   RUN
                      XEQ B
Σ=131,60

                69,50   RUN
                70,50   RUN
                      XEQ B
Σ=140,00

Σ.B=271,60

                68,70   RUN
                70,10   RUN
                      XEQ B
Σ=138,80

                73,80   RUN
                74,60   RUN
                      XEQ B
Σ=148,40

Σ.B=287,20


Σ.A=270,40
Σ.A=288,40
ANVA
```

Model I A

```
FACT.A
D.L.=1,000
S.C.=40,500
C.M.=40,500
F=64,286
P=0,002

FACT.B
D.L.=1,00
S.C.=30,42
C.M.=30,42
F=48,29
P=0,003

INT.A*B
D.L.=1,00
S.C.=0,18
C.M.=0,18
F=0,29
P=0,39

ERR.
D.L.=4,00
S.C.=2,52
C.M.=0,63

TOT.
D.L.=7,00
S.C.=73,62
```

Model II C

```
FACT.A
D.L.=1,000
S.C.=40,500
C.M.=40,500
F=75,000
P=0,001

FACT.B
D.L.=1,00
S.C.=30,42
C.M.=30,42
F=56,33
P=0,001

INT.A*B
D.L.=1,00
S.C.=0,18
C.M.=0,18
F=0,29
P=0,39

ERR.
D.L.=4,00
S.C.=2,52
C.M.=0,63

TOT.
D.L.=7,00
S.C.=73,62
```

Mixed Model D

```
XEQ D

FACT.A
D.L.=1,000
S.C.=40,500
C.M.=40,500
F=75,000
P=0,001

FACT.B
D.L.=1,00
S.C.=30,42
C.M.=30,42
F=48,29
P=0,003

INT.A*B
D.L.=1,00
S.C.=0,18
C.M.=0,18
F=0,29
P=0,39

ERR.
D.L.=4,00
S.C.=2,52
C.M.=0,63

TOT.
D.L.=7,00
S.C.=73,62
```

(*) PHILIPPE p.197

EXAMPLE 2 - AxB significant (**)

```
                XEQ "ANVA6"
                2,00    RUN
                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
Σ=127,50

               45,30    RUN
               45,10    RUN
               46,40    RUN
                      XEQ B
Σ=136,80

Σ.B=264,30

               43,30    RUN
               43,90    RUN
               44,60    RUN
                      XEQ B
Σ=131,80

               44,60    RUN
               44,20    RUN
               45,50    RUN
                      XEQ B
Σ=134,30

Σ.B=266,10


Σ.A=259,30
Σ.A=271,10
ANVA
```

Model I
A

```
FACT.A
D.L.=1,000
S.C.=11,603
C.M.=11,603
FACT.B
D.L.=1,000
S.C.=0,270
C.M.=0,270
INT.A*B
D.L.=1,000
S.C.=3,853
C.M.=3,853
F=9,838
P=0,014

ERR.
D.L.=8,000
S.C.=3,133
C.M.=0,392

TOT.
D.L.=11,000
S.C.=18,860
```

Model II
C

```
FACT.A
D.L.=1,000
S.C.=11,603
C.M.=11,603
F=3,011
P=0,338

FACT.B
D.L.=1,00
S.C.=0,27
C.M.=0,27
F=0,07
P=0,327

INT.A*B
D.L.=1,00
S.C.=3,85
C.M.=3,85
F=9,84
P=0,01

ERR.
D.L.=8,00
S.C.=3,13
C.M.=0,39

TOT.
D.L.=11,00
S.C.=18,86
```

Mixed Model
D

XEQ D

```
FACT.A
D.L.=1,000
S.C.=11,603
C.M.=11,603
F=3,011
P=0,338

FACT.B
D.L.=1,00
S.C.=0,27
C.M.=0,27
F=0,69
P=0,435

INT.A*B
D.L.=1,00
S.C.=3,85
C.M.=3,85
F=9,84
P=0,01

ERR.
D.L.=8,00
S.C.=3,13
C.M.=0,39

TOT.
D.L.=11,00
S.C.=18,86
```

(**) PHILIPPE p.133

PROGRAM LISTING

STAT.10

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

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

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.10

```
286 RTN
287♦LBL E
288 STOP
289 ST- 23
290 Σ-
291 GTO 01
292♦LBL 11
293 "⊦="
294 ARCL X
295 AVIEW
296 RTN
297♦LBL 03
298 RCL 16
299 STO 01
300 RCL 15
301 RTN
302♦LBL 04
303 RCL 18
304 STO 01
305 RCL 23
306 RTN
307♦LBL 05
308 RCL 26
309 STO 01
310 RCL 25
311 RTN
312♦LBL 06
313 RCL 28
314 X<>Y
315 /
316 STO 05
317 "F"
318 XEQ 11
319 RCL 01
320 XEQ 10
321 "P"
322 XEQ 11
323 FIX 2
324 ADV
325 RTN
326♦LBL 10
327 2
328 ENTER↑
329 9
330 /
331 STO 02
332 RCL 00
333 /
334 STO 03
335 RCL 02
336 RCL 01
337 /
338 STO 02
339 1
340 -
341 CHS
342 RCL 05
343 3
344 1/X
345 Y↑X
346 *
347 1
348 RCL 03
349 -
350 -
351 STO 07
352 RCL 02
353 RCL 05
354 2
355 ENTER↑
356 3
357 /
358 Y↑X
359 *
360 RCL 03
361 +
362 SQRT
363 RCL 07
364 X<>Y
365 /
366 STO 00
367 "X)0?"
368 SF 04
369 ABS
370 1
371 RCL 00
372 ,196854
373 *
374 +
375 RCL 00
376 X↑2
377 ,115194
378 *
379 +
380 RCL 00
381 3
382 Y↑X
383 ,000344
384 *
385 +
386 RCL 00
387 4
388 Y↑X
389 ,019527
390 *
391 +
392 -4
393 Y↑X
394 2
395 /
396 CHS
397 1
398 +
399 FIX 3
400 FS?C 04
401 XEQ 12
402 RTN
403♦LBL 12
404 1
405 X<>Y
406 -
407 RTN
408 .END.
```

REGISTERS, STATUS, FLAGS

STAT.10

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

Registers
Datenspeicher
Registres de données
Registri

00	T_a	50	
	.		
	.		
	.		
	.		
05	.	55	
	.		
	.		
	.		
	.		
10	T_b	60	
	T_g^2/n		
	T_b^2/an		
	T_a^2/bn		
15	Error M.S.	65	
	Error d.f.		
	Error S.S.		
	Interct. d.f.		
20	a	70	
	b		
	n		
	C.F.		
	pooled var.		
25	pooled d.f.	75	
	P interact.		
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 030 Total Reg. _____ **User Mode**

Eng ☐	Fix ☒	Sci ☐		On ☒
Deg ☐	Rad ☐	Grad ☐		Off ☐

Purpose Bedeutung Signification Scopo		**Flags** SET	CLEAR	
00				
01	Model II	X		
02	Model I	X		
03	AxB signif.	X		
04	P(F)	X		
05				
06				
07				
08				
09				
10				
11	Audio execute			
12				
13				
14				
15				
16				
17				
18				
19				
20				
21	Printer Enable			
22	Number Input			
23	Alpha Input			
24	Range Ignore			
25	Error Ignore			
26	Audio Enable			
27	User Mode			
28	Decimal Point			
29	Digit Grouping			

Assignments
Tastenbelegung/Assignations/Assegnamenti

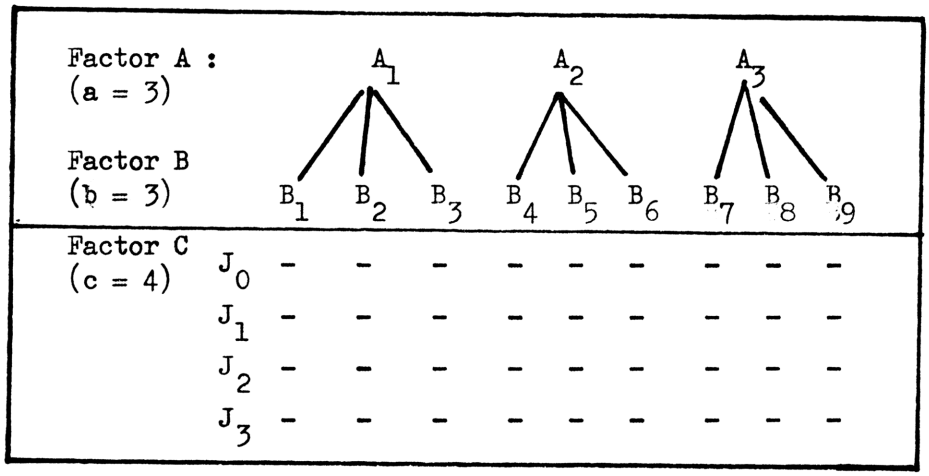
Function Funktion Fonction Funzione	**Key** Taste Touche Tasto	**Function** Funktion Fonction Funzione	**Key** Taste Touche Tasto

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.

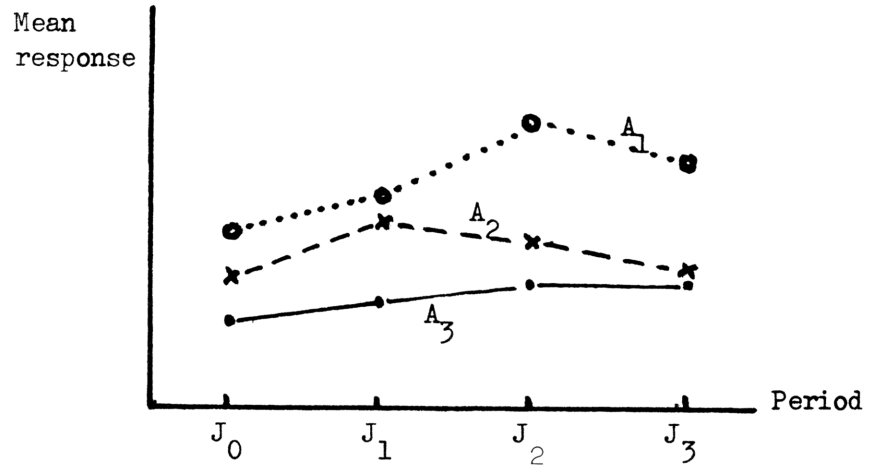


Each level of Factor A can be considered as a complete randomized block experiment, giving a tables such as :

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



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 maesurements (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^2_A	$s^2_A / s^2_{B(A)}$
B Between subgr. within groups (Error I)	a(b - 1)		$s^2_{B(A)}$	
C Between periods	(c - 1)		s^2_C	$s^2_C / s^2_{BC(A)}$
Interaction AxC	(a-1)(c-1)		s^2_{AC}	$s^2_{AC} / s^2_{BC(A)}$
Interaction BxC within groups (Error II)	a(b-1). (c-1)		$s^2_{BC(A)}$	
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.

USER INSTRUCTIONS I

STAT.11

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.11, tracks			
	1 to 6			
2	Initialize		XEQ"ANVA.7"	
3	Enter : levels of Factor A	a	R/S	
	levels of Factor C	c	R/S	
4	For the first level of Factor A,			
	enter : number of blocks	b	R/S	
5	Input the data of the first row	y_i.....	R/S	
6	Call		B	
	Display : row total T_b			Σ B
7	Correction routine			
	If a wrong data has been entered,			
	call immediately		E	
	input the erroneous data	y_E	R/S	
	then the correct one	y_C	R/S	
8	Repeat steps 5 and 6 for the other			
	rows			
9	At the end of the last row,			
	display of : the column totals			Σ T
	column means			MOY
10	Repeat steps 4 to 9 for the other			
	levels of A			
11	At the end of the last table,			
	Display of the ANOVA			
12	For another set of data, call		A	
	and return to step 3			

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	ΣT=21,61
	3	4,47	3,79	3,94	3,14	MOY=7,20
	4	4,66	4,40	3,76	4,35	ΣT=19,71
	6	5,13	4,28	3,79	3,53	MOY=6,57
						ΣT=18,61
A_2	2	7,27	6,86	5,99	5,54	MOY=6,20
	5	6,60	5,98	6,02	5,47	ΣT=17,74
	7	7,74	6,87	6,60	6,73	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
ΣB=12,63

4,47    RUN
3,79    RUN
3,94    RUN
3,14    RUN
     XEQ B
ΣB=15,34

4,66    RUN
4,40    RUN
3,76    RUN
4,35    RUN
     XEQ B
ΣB=17,17

5,13    RUN
4,28    RUN
3,79    RUN
3,53    RUN
     XEQ B
ΣB=16,73
```

```
ΣT=17,63
MOY=4,41
ΣT=15,58
MOY=3,90
ΣT=14,72
MOY=3,68
ΣT=14,14
MOY=3,54

3,00    RUN

7,27    RUN
6,86    RUN
5,99    RUN
5,54    RUN
     XEQ B
ΣB=25,66

6,60    RUN
5,98    RUN
6,02    RUN
5,47    RUN
     XEQ B
ΣB=24,07

7,74    RUN
6,87    RUN
6,60    RUN
6,73    RUN
     XEQ B
ΣB=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 "ANVA7"
02♦LBL A
03 CLRG
04 STOP
05 STO 20
06 STOP
07 STO 21
08 13
09 X<=Y?
10 GTO 09
11 XEQ 07
12 ADV
13♦LBL 08
14 STOP
15 STO 30
16 ST+ 31
17 ADV
18♦LBL 01
19 STOP
20 ST+ IND 25
21 ISZ
22 ΣREG 14
23 Σ+
24 GTO 01
25♦LBL B
26 RCL 15
27 ST+ 13
28 RCL 14
29 "ΣB"
30 XEQ 11
31 ADV
32 ST+ 22
33 X↑2
34 ST+ 23
35 CLΣ
36 0
37 STO 25
38 1
39 ST+ 24
40 RCL 24
41 RCL 30
42 X>Y?
43 GTO 01
44 0
45 STO 24
46♦LBL 02
47 RCL IND 25
48 "ΣT"
49 XEQ 11
50 RCL 30
51 /
52 "MOY"
53 XEQ 11
54 RCL IND 25
55 ST+ IND 27
56 ISG 27
57 X↑2
58 ST+ 24
59 ISZ
60 RCL 25
61 RCL 21
62 X>Y?
63 GTO 02
64 RCL 22
65 X↑2
66 RCL 21
67 RCL 30
68 *
69 /
70 STO 22
71 ST+ 29
72 RCL 13
73 RCL 22
74 -
75 STO 13
76 RCL 23
77 RCL 21
78 /
79 RCL 22
80 -
81 STO 23
82 ST+ 26
83 RCL 24
84 RCL 30
85 /
86 RCL 22
87 -
88 STO 24
89 ST+ 33
90 RCL 13
91 RCL 23
92 RCL 24
93 +
94 -
95 ST+ 28
96 0
97 STO 00
98 STO 01
99 STO 02
100 STO 03
101 STO 04
102 STO 05
103 STO 06
104 STO 07
105 STO 08
106 STO 09
107 STO 10
108 STO 11
109 STO 12
110 STO 13
111 STO 22
112 STO 23
113 STO 24
114 STO 25
115 CLΣ
116 XEQ 07
117 1
118 ST+ 32
119 RCL 32
120 RCL 20
121 X>Y?
122 GTO 08
123 0
124 STO 00
125 STO 01
126♦LBL 06
127 RCL IND 27
128 ST+ 00
129 X↑2
130 ST+ 01
131 ISG 27
132 RCL 27
133 35
134 -
135 RCL 21
136 X>Y?
137 GTO 06
138 ADV
139 RCL 00
140 X↑2
141 RCL 21
142 /
143 RCL 31
144 /
145 STO 10
146 RCL 20
147 1
148 -
149 STO 02
150 ST+ 09
151 RCL 29
152 RCL 10
153 -
154 STO 03
155 ST+ 08
156 RCL 26
157 RCL 31
158 RCL 20
159 -
160 STO 04
161 /
162 STO 11
163 "ANVA"
164 AVIEW
165 "A"
166 AVIEW
167 XEQ 05
168 XEQ 04
169 "ERR.B<A>"
170 AVIEW
171 RCL 04
172 ST+ 09
173 STO 02
174 RCL 26
175 ST+ 08
176 STO 03
177 XEQ 05
178 ADV
179 RCL 21
180 1
181 -
182 STO 02
183 ST+ 09
184 RCL 01
185 RCL 31
186 /
187 RCL 10
188 -
189 STO 03
190 ST+ 08
191 RCL 28
192 RCL 04
193 RCL 02
194 *
195 STO 04
196 /
197 STO 11
198 "C"
199 AVIEW
200 XEQ 05
201 XEQ 04
202 "A*C"
203 AVIEW
204 RCL 20
205 1
206 -
207 RCL 21
208 1
209 -
210 *
211 STO 02
212 ST+ 09
213 RCL 33
214 RCL 03
215 -
216 STO 03
217 ST+ 08
218 XEQ 05
219 XEQ 04
220 "ERR.B*C<A>"
221 AVIEW
222 RCL 04
223 ST+ 09
224 STO 02
225 RCL 28
226 ST+ 08
227 STO 03
228 XEQ 05
229 ADV
230 "TOT"
231 AVIEW
232 RCL 09
233 "D.L."
234 XEQ 11
235 RCL 08
236 "S.C."
237 XEQ 11
238 RTN
239♦LBL 07
240 35,050
241 STO 27
242 RTN
243♦LBL 05
244 RCL 02
245 "D.L."
246 XEQ 11
247 RCL 03
248 "S.C."
249 XEQ 11
250 X<>Y
251 /
252 "C.M."
253 XEQ 11
254 RTN
255♦LBL 04
256 RCL 11
257 /
258 STO 05
259 "F"
260 XEQ 11
261 XEQ 10
262 RTN
263♦LBL 10
264 2
265 ENTER↑
266 9
267 /
268 STO 35
269 RCL 02
270 /
271 STO 36
272 RCL 35
273 RCL 04
274 /
275 STO 35
276 1
277 -
278 CHS
279 RCL 05
280 3
281 1/X
282 Y↑X
283 *
284 1
285 RCL 36
```

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.11

```
286 -
287 -
288 STO 37
289 RCL 35
290 RCL 05
291 2
292 ENTER↑
293 3
294 /
295 Y↑X
296 *
297 RCL 36
298 +
299 SQRT
300 RCL 37
301 X<>Y
302 /
303 STO 38
304 X>0?
305 SF 02
306 ABS
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
343 RTN
344◆LBL 12
345 1
346 X<>Y
347 -
348 RTN
349◆LBL 11
350 "⊢="
351 ARCL X
352 AVIEW
353 RTN
354◆LBL E
355 RCL 25
356 1
357 -
358 STO 25
359 STOP
360 ST- IND 25
361 Σ-
362 GTO 01
363 .END.
```

STAT.11

REGISTERS, STATUS, FLAGS

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

Registers
Datenspeicher
Registres de données
Registri

00	T_c	50	
	•		
	•		
	•		
05		55	
10		60	
	•		
	•		
	Σy^2		
15		65	
20	a	70	
	c		
	Σy		
	ΣT_b^2		
	ΣT_c^2		
25		75	
	Blocks S.S.		
	S.S. BC(A)		
	S.S. A		
30	b	80	
	Σb		
35	T_c	85	
	mean		
	•		
	•		
	•		
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 050 Total Reg. _____ **User Mode**

Eng ☐ Fix ☒ Sci ☐ On ☒

Deg ☐ Rad ☐ Grad ☐ Off ☐

Purpose (Bedeutung / Signification / Scopo) — **Flags**

	Purpose	SET	CLEAR
00			
01			
02	P(F) routine	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
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)

STAT.L2

FACTORIAL EXPERIMENTS

DESCRIPTION

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 :

$2^3 = 8$ for 3 factors

$2^4 = 16$ for 4 factors

$2^5 = 32$ 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,

$A_0B_1C_1D_0$ = bc $A_1B_1C_1D_1$ = abcd $A_0B_0C_0D_0$ = (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 correponding 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 "ANVA8"	
3	Enter : number of factors	f	R/S	
	number of replicates	n	R/S	
	$\underline{n = 1}$			
4	Input the data in systematic order	y ...	R/S	
	$\underline{n \geq 1}$			
4'	Input the replicates of the first treatment (1)	y_i...	R/S	
	then call		B	
4"	Repeat step 4' for the other treatments 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 interaction; then Error :			
	nber of d.f.			D.L.
	mean square			C.M.
6	For another set of data, call and return to step 3		A	

STAT.12

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
```

PHILIPPE p.204

EXAMPLE 2 - Three factors; n = 2 (**)

```
  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
```

(**) PHILIPPE p.207

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA


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

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.12

```
286 GTO 26
287 "AE"
288 AVIEW
289 XEQ 19
290 RCL 63
291 XEQ 23
292 "BE"
293 AVIEW
294 RCL 64
295 XEQ 19
296 RCL 64
297 XEQ 23
298 "CE"
299 AVIEW
300 RCL 66
301 XEQ 19
302 RCL 66
303 XEQ 23
304 "DE"
305 AVIEW
306 RCL 70
307 XEQ 19
308 RCL 70
309 XEQ 23
310◆LBL 26
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 X↑2
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
343 /
344 STO 03
345 RTN
346◆LBL 19
347 RCL 04
348 /
349 "MOY"
350 XEQ 11
351 RTN
352◆LBL 23
353 X↑2
354 RCL 07
355 /
356 "CM"
357 XEQ 11
358 RCL 03
359 /
360 "F"
361 XEQ 11
362 RTN
363◆LBL 11
364 "├="
365 ARCL X
366 AVIEW
367 RTN
```

REGISTERS, STATUS, FLAGS

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

STAT.12

Registers
Datenspeicher
Registres de données
Registri

00	2^k	50	
	n		
	Σ y		
	Σ y^2		
	div. T		
05		55	
	div. T^2		
	k		
	Σ T_g^2		
10		60	
	Data to		
	42		
15		65	
20		70	
25		75	

30		80	
35		85	
40		90	

45	Data to	95	
	77		
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 080 Total Reg. 179 **User Mode**

Eng ☐	Fix ☒	Sci ☐		On ☒
Deg ☐	Rad ☐	Grad ☐		Off ☐

Purpose
Bedeutung
Signification
Scopo

Flags

	Purpose	SET	CLEAR
00	Service	X	
01	"	X	
02	"	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
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

STAT.13

PRODUCT-MOMENT CORRELATION COEFFICIENT

When studying corrélation, 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 :

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

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 :

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

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

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 $\underline{z}$ (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.

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 - Ungrouped data			
3	Call		A	
4	Input the pairs of data	y_{i1}	R/S	
		y_{i2}	R/S	
5	Correction routine			
	Input the complete pair and call		E	
	input the erroneous pair	y_{1E}	R/S	
		y_{2E}	R/S	
	then the correct one			
6	After the last pair, call		B	
	Display of : means			MOY.1
				MOY.2
	standard deviations			D.S.1
				D.S.2
	covariance			COV.1.2
	correlation coefficient			r 1.2
	b - Grouped data			
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 corresponding 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	Correction routine			
	Complete the entry of the erroneous group and call		E	
	Input again :	y'_{1E}	R/S	
		y'_{2E}	R/S	
		f_E	R/S	
	then the correct group :	y'_{1C}	R/S	
		y'_{2C}	R/S	
		f_C	R/S	
14	After the last column, call		D	
	Display of : sample size			Σf
	correlation coeff.			r 1.2

USER INSTRUCTIONS

STAT.13

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
	Test : $\rho = 0$?			
15	Call		F	
	Display : t			t
	P(t)			P
	If $P(t) < \alpha$, ρ is different from 0			
	Test : $\rho = \rho_1$? $(n \geq 25)$			
16	Call		G	
	Enter the value of ρ_1	ρ_1	R/S	
	Display : normal deviate			u
	P(u)			P
	If $P(u) < \alpha$, ρ is different from the value ρ_1			
	Comparison between r_1 and r_2			
17	Call		H	
18	Enter : first coefficient	r_1	R/S	
	second coefficient	r_2	R/S	
	sample size 1	n_1	R/S	
	sample size 2	n_2	R/S	
19	Display : normal deviate			u
	P(u)			P
	If $P(u) < \alpha$, ρ_1 and ρ_2 differ significantly			
20	For another set of data, return to step 3 or 7			

STAT.13

EXAMPLE 1 - Ungrouped data (*)

```
          XEQ "CORR"
40,00      RUN
95,00      RUN

(error)    8,00    RUN
          35,00    RUN

          XEQ E
 8,00      RUN
35,00      RUN
-8,00      RUN
35,00      RUN

27,00      RUN
15,00      RUN

75,00      RUN
110,00     RUN

62,00      RUN
105,00     RUN

 5,00      RUN
20,00      RUN

60,00      RUN
70,00      RUN

43,00      RUN
90,00      RUN

70,00      RUN
100,00     RUN

 5,00      RUN
45,00      RUN

50,00      RUN
45,00      RUN

45,00      RUN
55,00      RUN

20,00      RUN
45,00      RUN

          XEQ B
MOY.1=38,00
MOY.2=63,85

D.S.1=26,48
D.S.2=33,05
COV.1.2=680,42

r.1.2=0,78
```

$\rho = 0$?

```
          XEQ F
t=4,10
P=0,002
```

EXAMPLE 2 - Grouped data (**)

y_2 \ y_1	5 000	5 100	5 200	5 300	5 400	5 500	5 600	5 700	5 800	5 900	6 000	6 100	6 200
y'_2 / y_2	− 6	− 5	− 4	− 3	− 2	− 1	0	1	2	3	4	5	6
3 500 5							1						
3 400 4								2					3
3 300 3								1			2	3	
3 200 2						1	1	1	2	4	2	2	
3 100 1					1	2	3	2	5	3	1		
3 000 0				1	2	2	4	4	2	3	2		
2 900 − 1				1	3	3	4	2	1				
2 800 − 2			1	3	3	1	1						
2 700 − 3			2	1	2	1	1						
2 600 − 4		1	1	2	1								
2 500 − 5	1	2											

```
          XEQ "CORR"
          XEQ C
5,00       RUN
0,00       RUN
1,00       RUN

          XEQ B
4,00       RUN
1,00       RUN
2,00       RUN

6,00       RUN
3,00       RUN

          XEQ B
3,00       RUN
1,00       RUN
1,00       RUN
```

(*) PHILIPPE p.153 (**) p.158

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

      XEQ B
      RUN
-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
```

```
                    XEQ D
Σf=100,00
r.1.2=0,78

ρ = 0 ?

                    XEQ F
t=12,43
P=9,000E-10

ρ = ρ1 ?

                    XEQ G
          0,60      RUN
u=3,53
P=0,001

r1 = r2 ?

                    XEQ H
       0,6213       RUN
       0,8017       RUN
        36,00       RUN
        17,00       RUN
u=-1,18
P=0,239
```

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.13

```
01♦LBL "CORR"
02♦LBL A
03 CF 00
04 CLRG
05♦LBL 01
06 STOP
07 STOP
08 X<>Y
09 ΣREG 14
10 Σ+
11 ADV
12 GTO 01
13♦LBL B
14 MEAN
15 "MOY.1"
16 XEQ 11
17 STO 20
18 X<>Y
19 "MOY.2"
20 XEQ 11
21 ADV
22 SDEV
23 "D.S.1"
24 XEQ 11
25 STO 22
26 X<>Y
27 "D.S.2"
28 XEQ 11
29 STO 23
30 RCL 18
31 RCL 14
32 RCL 16
33 *
34 RCL 19
35 /
36 -
37 RCL 19
38 1
39 -
40 /
41 "COV.1.2"
42 XEQ 11
43 ADV
44 RCL 22
45 RCL 23
46 *
47 /
48 STO 00
49 SF 13
50 "R.1.2"
51 XEQ 11
52 CF 13
53 ADV
54 RTN
55♦LBL C
56 CLRG
57 SF 00
58♦LBL 02
59 STOP
60 STO 20
61♦LBL 07
62 STOP
63 STO 21
64 STOP
65 STO 22
66 ST+ 19
67 RCL 20
68 *
69 *
70 ST+ 02
71 RCL 21
72 RCL 22
73 *
74 ST+ 03
75 RCL 21
76 *
77 ST+ 04
78 RCL 22
79 RCL 20
80 *
81 ST+ 05
82 RCL 20
83 *
84 ST+ 06
85 ADV
86 GTO 07
87♦LBL B
88 GTO 02
89♦LBL D
90 RCL 06
91 RCL 05
92 X↑2
93 RCL 19
94 /
95 -
96 STO 06
97 RCL 04
98 RCL 03
99 X↑2
100 RCL 19
101 /
102 -
103 STO 04
104 RCL 02
105 RCL 03
106 RCL 05
107 *
108 RCL 19
109 SF 13
110 "ΣF"
111 XEQ 11
112 /
113 -
114 RCL 06
115 RCL 04
116 *
117 SQRT
118 /
119 STO 00
120 "R.1.2"
121 XEQ 11
122 ADV
123 CF 00
124 CF 13
125 RTN
126♦LBL F
127 RCL 00
128 RCL 19
129 2
130 -
131 STO 01
132 1
133 RCL 00
134 X↑2
135 -
136 /
137 SQRT
138 *
139 SF 13
140 "T"
141 XEQ 11
142 CF 13
143 ABS
144 RCL 01
145 RAD
146 SQRT
147 /
148 ATAN
149 STO 02
150 RCL 01
151 2
152 /
153 INT
154 LASTX
155 X≠Y?
156 GTO 04
157 0
158 STO 05
159♦LBL 16
160 RCL 02
161 COS
162 X↑2
163 STO 03
164 RCL 02
165 SIN
166 STO 04
167 RCL 01
168 2
169 X=Y?
170 GTO 08
171 /
172 1
173 -
174 STO 25
175 1
176 STO 06
177♦LBL 03
178 RCL 03
179 *
180 RCL 05
181 1
182 +
183 *
184 LASTX
185 1
186 +
187 STO 05
188 /
189 ST+ 06
190 7DSZ
191 GTO 03
192 RCL 06
193 RCL 04
194 *
195 FS? 01
196 GTO 15
197 GTO 06
198♦LBL 15
199 RTN
200♦LBL 04
201 RCL 02
202 2
203 *
204 PI
205 /
206 STO 07
207 3
208 RCL 01
209 X=Y?
210 GTO 12
211 1
212 STO 05
213 ST- 01
214 X=Y?
215 GTO 09
216 SF 01
217 XEQ 16
218 CF 01
219♦LBL 13
220 RCL 02
221 COS
222 *
223 2
224 *
225 PI
226 /
227 RCL 07
228 +
229 GTO 06
230 RTN
231♦LBL 09
232 RCL 07
233 GTO 06
234♦LBL 08
235 RCL 04
236 GTO 06
237 RTN
238♦LBL 06
239 1
240 X<>Y
241 -
242 FS?C 02
243 XEQ 05
244 FIX 3
245 "P"
246 XEQ 11
247 FIX 2
248 RTN
249♦LBL 05
250 2
251 /
252 RTN
253♦LBL 12
254 RCL 02
255 SIN
256 GTO 13
257 RTN
258♦LBL 11
259 "⊦="
260 ARCL X
261 AVIEW
262 RTN
263♦LBL E
264 FS? 00
265 GTO 10
266 STOP
267 STOP
268 X<>Y
269 Σ-
270 GTO 01
271♦LBL 10
272 STOP
273 STO 20
274 STOP
275 STO 21
276 STOP
277 STO 22
278 ST- 19
279 *
280 *
281 ST- 02
282 RCL 21
283 RCL 22
284 *
285 ST- 03
```

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.13

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

STAT.13

REGISTERS, STATUS, FLAGS

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

Registers
Datenspeicher
Registres de données
Registri

00	r 12	50	
	n - 2		
	Σ f $y'_1y'_2$		
	$\Sigma fy'_2$		
	$\Sigma fy'^2_2$		
05	$\Sigma fy'_1$	55	
	$\Sigma fy'^2_1$		
10	t	60	
	statistic		
15	stack	65	
	.		
	.		
	.		
	Σ f		
20	y'_1 ; u	70	
	y'_2		
	f		
25		75	
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 026 Total Reg. _____ **User Mode**

Eng ☐ Fix ☒ Sci ☐ On ☒

Deg ☐ Rad ☒ Grad ☐ Off ☐

	Purpose (Bedeutung / Signification / Scopo)	Flags SET	Flags CLEAR
00	Grouped data	X	
01	P(t)	X	
02			
03	P(u)	X	
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
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)

LINEAR REGRESSION

DESCRIPTION

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 ajusted 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 : $a = \bar{\bar{y}} - bx$.

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 quares 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:

S.S. groups = $\Sigma\, T_g^2/n$ - C.F. (3)

S.S. deviation = (3) - (2)

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.

STAT.14

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 :

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

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 limits 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 :

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

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.

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	
	1- one value of Y per X			
4	Call		D	
5	Input the data by pairs	x_i	R/S	
		y_i	R/S	
6	Correction routine			
	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			
	2 - n responses Y per X			
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	
	Display : group total T_g			ΣY
13	Repeat steps 10 to 12 for the			
	other values of X			
14	Correction routine			
	Call		E	
	input the erroneous y	y_E	R/S	
	then the correct one			
15	After the last group, call		G	
	Display : Y-intercept	a	R/S	a
	slope			b
	ANOVA			
	Estimation of $\hat{Y}$			
16	Call		H	
17	Enter the value X	x	R/S	
	Display : calculated $\hat{Y}$			Y
	95 % confidence interval			L.I.
18	Repeat step 17 for other values			L.S.
	of X			

USER INSTRUCTIONS II

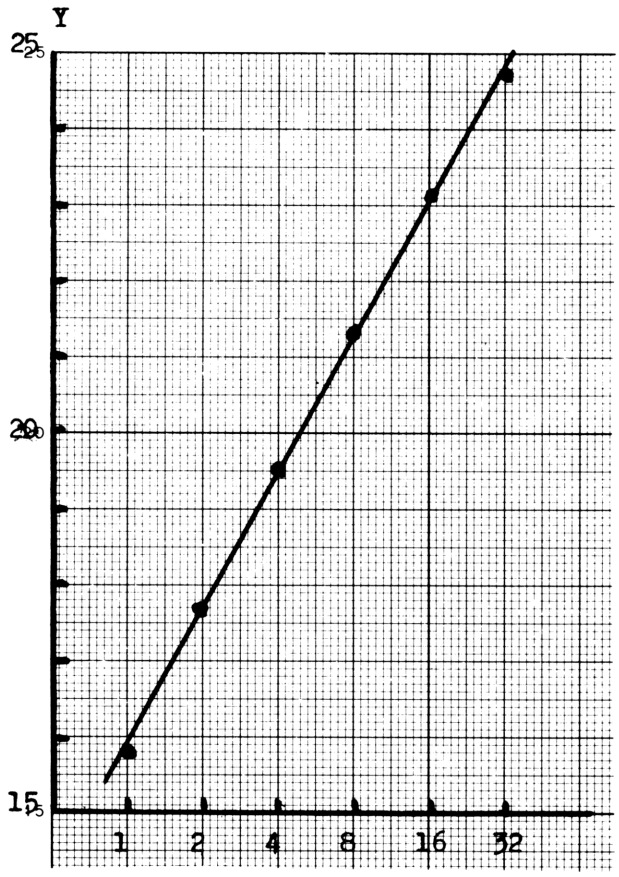
PROGRAMMABLAUF II
INSTRUCTIONS D'EMPLOI II
NORME OPERATIVE II

STAT.14

Step Schritt Pas Passo	**Instructions** Operation Instructions Istruzioni	**Variables** Dateneingabe Données Dati	**Function(s)** Taste(n) Touche(s) Tasti	**Result** Resultat Résultat Risultato
	Estimation of $\hat{X}$			
19	Call		I	
20	input the value of Y	y	R/S	
20'	or input the m values of Y	$y_1 \ldots . y_m$	R/S	
	then call		J	
21	Display of : calculated $\hat{X}$			X
	95 % confidence interval			L.I.
				L.S.
22	For another set of data, call		p.A	
	and return to step 3			

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




```
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 C
```

```
ANY?

REG.
D.L.=1,00
S.C.=55,59
C.M.=55,59
F=8,906,16
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
```

a=15,95
b=5,92

Estimation $\hat{Y}$

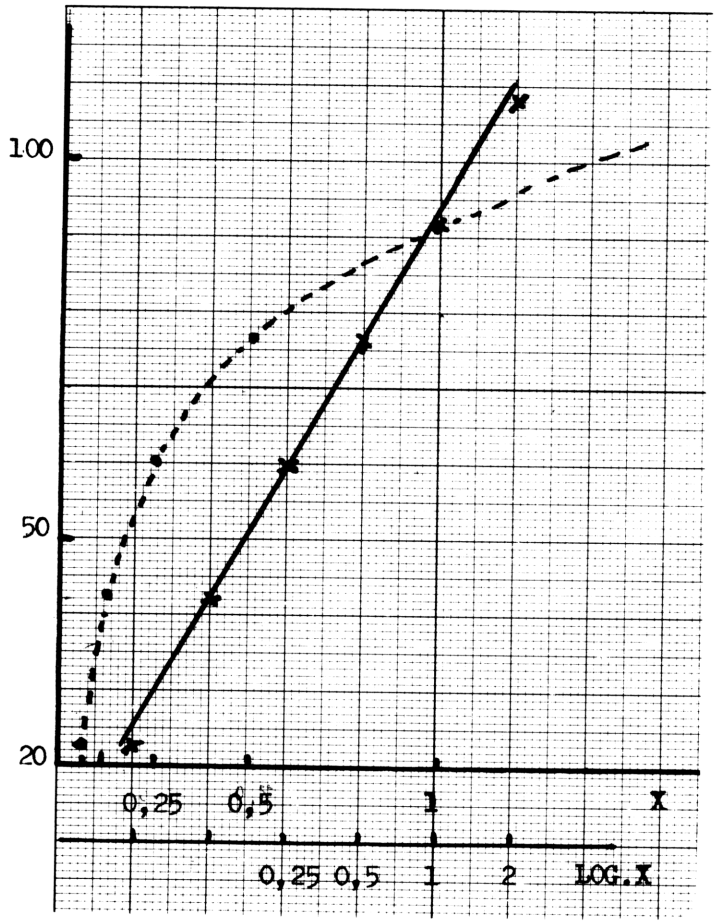
```
     XEQ H
10,00  RUN
Y=21,87
S.E.Y=0,03
L.I.=21,77
L.S.=21,96
```

Estimation $\hat{X}$

```
     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 "REGP"
     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
```

(error)

```
   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
     XEQ G
a=42,37
b=38,40

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.=5.189,97
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
```

(*) PHILIPPE p.168

EXAMPLE 2 - Same data; log.transform

```
                XEQ F
                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
         63,00    RUN
         58,00    RUN
         58,00    RUN
         66,00    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

                XEQ G
a=93,12
b=56,59


ANVA

REG.
D.L.=1,00
S.C.=25.389,60
C.M.=25.389,60
F=2.040,80
P=2,097E-4

DEV.
D.L.=4,00
S.C.=49,76
C.M.=12,44
F=1,04
P=0,406

ERR.
D.L.=24,00
S.C.=286,00
C.M.=11,92

TOT.
D.L.=29,00
S.C.=25.725,37
```

Estimation $\hat{Y}$

```
                XEQ H
         0,55    RUN
Y=78,43
S.E.Y=0,67
L.I.=77,04
L.S.=79,81
```

Estimation $\hat{X}$

```
                XEQ I
        80,00    RUN
        82,00    RUN
        83,00    RUN
        85,00    RUN
        89,00    RUN
                XEQ J
X=0,68
S.E.X=0,03

L.I.=0,59
L.S.=0,79
```

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.14

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

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.14

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

REGISTERS, STATUS, FLAGS

STAT.14

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

Registers
Datenspeicher
Registres de données
Registri

00	$\bar{x}$	50	
	$\bar{y}$		
	S.S.regression		
05	S.S.deviation	55	
	M.S.deviation		
	S.S.error		
	d.f.error		
	P		
10	S.S. x	60	
	S.P. xy		
	Total S.S.		
	Group S.S.		
	Σ x		
15	Σ x^2	65	
	F		
	Σ y^2		
	Σ xy		
	Σ n		
20	k	70	
	b		
	M.S.error		
	a		
	$d.f._1$		
25		75	
	$d.f._2$		
	F routine		
	•		
	•		
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 030 Total Reg. _____ **User Mode**

Eng ☐	Fix ☒	Sci ☐	On ☒
Deg ☐	Rad ☐	Grad ☐	Off ☐

Purpose / Flags
Bedeutung
Signification
Scopo

	Purpose	SET	CLEAR
00	log.x	X	
01	one X per X	X	
02	P(F) routine	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
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

STAT.15

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 :

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

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 :

$$L^2 = (Exy)^2 / Exx$$

By removing this quantity from the error SS Eyy, we obtain a S.S. of error adjusted for the regression. This new S.S. (Ex.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 :

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

These $\bar{y}_{adj.}$ 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 :

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

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

STAT.15

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_i	R/S	
		y_i	R/S	
5	Correction routine			
	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			
6	After the last pair of the group, call		B	
	Display : sum of X			Σ X
	mean X			MOY.X
	sum of Y			Σ Y
	mean 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			F
	P(F)			P
10	Test : difference among treatments			
	Adjusted S.S. y			S.C.
	" M.S. y			C.M.
	F			F
	P(F)			P
11	Display : Adjusted means			MOY.
12	Test : difference of means			
	Display : corrected standard dev.			s
	Input : the means to be compared	$\bar{y}_1$	R/S	
		$\bar{y}_2$	R/S	
	the sample sizes	n_1	R/S	
		n_2	R/S	
	Display : calculated "t"			t
	limit value "t" 0,05			$t_{0,05}$
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
ΣX=25,50
MOY.X=3,19
ΣY=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
ΣX=29,40
MOY.X=3,68
ΣY=227,50
MOY.Y=28,44
```

```
                1,80    RUN
               32,50    RUN
                2,30    RUN
               29,20    RUN
                7,00    RUN
               30,40    RUN
               11,90    RUN
               22,50    RUN
(error)        13,40    RUN
               27,30    RUN
                       XEQ E
               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 B
ΣX=34,90
MOY.X=4,36
ΣY=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
```

PHILIPPE p.176

PROGRAM LISTING

STAT.15

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

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

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.15

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

REGISTERS, STATUS, FLAGS

STAT.15

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

Registers
Datenspeicher
Registres de données
Registri

00	n	50	
	total SS X		
	treat.SS X		
	error SS X		
	treat. d.f.		
05	$(\Sigma x \Sigma y)$	55	
	treat. SP		
	error d.f.		
	a		
	L^2		
10		60	
	total SS Y		
	treat.SS Y		
	error SS Y		
	total SP		
15		65	
	error SP		
20	Σ x	70	
	Σ x^2		
	Σ y		
	Σ y^2, err.s^2		
	Σ xy; $\bar{\bar{x}}$		
25		75	
	b		
	adj.treat.SS		
30	$\bar{\bar{y}}_1$	80	
	n_1		
	.		
	.		
	.		
35	.	85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 055 Total Reg. _____ **User Mode**

Eng ☐ Fix ☒ Sci ☐ On ☒

Deg ☐ Rad ☐ Grad ☐ Off ☐

Purpose
Bedeutung
Signification
Scopo

Flags

		SET	CLEAR
00			
01			
02	P(F) routine	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
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

STAT.17

NON-PARAMETRIC RANK TESTS

DESCRIPTION

When the conditions of the parametic 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 ore more observations have the same value (tied observations), they are given the average of the ranks they would have if no ties had occured.

MANN-WHITNEY "U" TEST

This is the equivalent of the "t" test for two independant 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 :

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

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

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 differenee 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).

KRUSKALL-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 :

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

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

STAT.17

PROGRAMMABLAUF II
INSTRUCTIONS D'EMPLOI II
NORME OPERATIVE II

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 program STAT.17, tracks			
	1 to 6			
2	Initialize		XEQ "RANG"	
	MANN-WHITNEY			
3	Call		A	
4	Enter : nber of groups	2	R/S	
5	Input the ranks of the 1st group	x_i.....	R/S	
6	After the last rank, call		B	
	display of : rank total			R
	n			n
	Correction routine			
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"			U
	if $n_2 > 20$ z			z
	P(z)			P
10	For another set of data, return			
	to step 3			
	WILCOXON			
11	Call		D	
12	Input the positive ranks	+ x_i....	R/S	
13	Call		B	
	Display : rank total			R
	n			n
14	Input the negative ranks	- x_i....	R/S	
15	Call		B	
	Display : R			R
	n			n
	statistic "T"			T
	z			z
	P(z) one-tailed			P.UNI
	P(z) two-tailed			P.BIL.
16	For another set of data, return to			
	step 11			
	KRUSKALL-WALLIS			
17	Call		A	
18	Enter : nber of groups	a	R/S	
19	Input ranks of 1st group	x_i	R/S	
20	After the last rank, call		B	
	Display : rank total			R
	n			n
21	Repeat steps 19 and 20 for the			
	other groups			

USER INSTRUCTIONS II

STAT.17

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	Correction routine			
	see step 7			
23	After the last group,			
	display : statistic "H"			H
	P(H)			P
24	For another set of data, return to			
	step 17			
	FRIEDMAN			
25	Call		C	
26	Enter : nber columns	a	R/S	
	nber rows	b	R/S	
27	Input ranks of the first column	x_i ...	R/S	
28	Call		B	
	Display : rank total			R
	n			n
29	For the other groups, repeat			
	steps 27 and 28			
30	Correction routine			
	see step 7			
31	After the last group, display :			
	X_r^2			X2
	$P(X_r^2)$			P
32	For another set of data, return to			
	step 25			

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
                   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
```

(*) S.SIEGEL pp. 120 and 122

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

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.17

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

REGISTERS, STATUS, FLAGS

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

STAT.17

Registers
Datenspeicher
Registres de données
Registri

00		50	
	1 to 10		
	R_j		
05		55	
10	----------	60	
	11 to 19		
	n		
15		65	

20	a	70	
25		75	
	$U; \quad R^2/n$		
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 030 Total Reg. 177 **User Mode**

Eng ☐	Fix ☒	Sci ☐		On ☒
Deg ☐	Rad ☐	Grad ☐		Off ☐

Purpose
Bedeutung
Signification
Scopo

Flags

	Purpose	SET	CLEAR
00	Friedman	X	
01	Wilcoxon	X	
02			
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
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

NON PARAMETRIC TESTS

ANALYSIS OF FREQUENCIES

DESCRIPTION

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 X^2 test

The statistic $X^2 = \sum_{k} \frac{(f_o - f_t)^2}{f_t}$ 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 that 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 independance

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 contigency table.

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

Such a table is called an (r x 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 x 2) contingency table like the following one :

	Treatments 1	2	Totals
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 independant.

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".

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 :

$$G = 2\left[(\Sigma f_o \text{LN } f_o) - (\Sigma T_c \text{LN } T_c) - (\Sigma T_r \text{LN } T_r) + N \text{ LN } N\right]$$

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.

USER INSTRUCTIONS I

STAT.18

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"	
	1 - Test of Goodness of fit			
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
	If $P(G)<\alpha$, H_0 is rejected			
7	For another set of data, return to step 3			
	2 - Table (2 x 2)			
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)
	a - Fisher exact test			
10	Call		D	
	Display : prob. one-tailed test			P.UNI
	prob. two-tailed test			P.BIL
	b - X^2 test			
11	Call		F	
12	Display of : calculated X^2			X^2
	prob. X^2			P
	If $P(X^2) < \alpha$, H_0 is rejected			
13	For another set of data, return to step 8.			
	3 - Table (r x c) ($c \leq 12$)			
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	

USER INSTRUCTIONS II

PROGRAMMABLAUF II
INSTRUCTIONS D'EMPLOI II
NORME OPERATIVE II

STAT.18

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		H	
	Display of : row total T_r			Σ R
18	Correction routine			
	After entering a wrong f, call		E	
	input the erroneous frequency	f_E	R/S	
	then the correct one	f_C	R/S	
19	Repeat steps 16 and 17 for the			
	other rows			
20	After the last row,			
	Display of : the column totals T_c			Σ C
	the grand total			N
	G			G
	number of d.f.			D.L.
	P(G)			P
	If $P(G)<\alpha$, H_0 is rejected			
21	For another set of data, return to			
	step 14			

STAT.18

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) X^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

X2=2.96
P=0.085
```

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

```
                XEQ G
          4,00   RUN
          3,00   RUN

        125,00   RUN
         53,00   RUN
         18,00   RUN
          4,00   RUN
                XEQ H
ΣR=200,00

        112,00   RUN
         59,00   RUN
         22,00   RUN
          7,00   RUN
                XEQ H
ΣR=200,00
```

(error)

```
        128,00   RUN
        157,00   RUN
                XEQ e
        157,00   RUN
         57,00   RUN
         10,00   RUN
          5,00   RUN
                XEQ H
ΣR=200,00

ΣC=365,00
ΣC=169,00
ΣC=50,00
ΣC=16,00

N=600,00

G=7,17
D.L.=6,00
P=0,306
```

(*) PHILIPPE p.47 (**) PHILIPPE p.44

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.18

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

Please use paper glue to attach listings. Adhesive tape may affect print!
Bitte Listings mit Papierleim einkleben. Klebefilme können Druck bleichen!

S.V.P. utilisez de la colle à papier pour fixer les listings. Les rubans adhésifs peuvent altérer l'impression!
Per favore usare la colla per fissare i listati. Il nastro adesivo puo alterare lo stampato!

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.18

```
286 1/X
287 *
288 STO 02
289 RTN
290♦LBL 04
291 1
292 RCL 26
293 .196854
294 *
295 +
296 RCL 26
297 X↑2
298 .115194
299 *
300 +
301 RCL 26
302 3
303 Y↑X
304 .000344
305 *
306 +
307 RCL 26
308 4
309 Y↑X
310 .019527
311 *
312 +
313 -4
314 Y↑X
315 2
316 /
317 CHS
318 1
319 +
320 1
321 X<>Y
322 -
323 STO 07
324 RTN
325♦LBL 08
326 XEQ 04
327 2
328 *
329 GTO 09
330♦LBL 17
331 XEQ 02
332 RCL 10
333 RCL 02
334 *
335 GTO 09
336♦LBL 11
337 "Ŷ="
338 ARCL X
339 AVIEW
340 RTN
341♦LBL C
342 CLRG
343 STOP
344 STO 22
345 13
346 X<=Y?
347 GTO 19
348 STOP
349 STO 21
350 ADV
351 ADV
352♦LBL 20
353 STOP
354 X≠0?
355 SF 02
356 ST+ 13
357 ST+ IND 25
358 ?ISZ
359 XEQ 21
360 GTO 20
361♦LBL H
362 RCL 13
363 "ΣR"
364 XEQ 11
365 ADV
366 ST+ 14
367 XEQ 22
368 0
369 STO 13
370 STO 25
371 1
372 ST+ 15
373 RCL 21
374 RCL 15
375 X≠Y?
376 GTO 20
377♦LBL 23
378 RCL IND 25
379 "ΣD"
380 XEQ 11
381 XEQ 22
382 ?ISZ
383 RCL 23
384 RCL 25
385 X≠Y?
386 GTO 23
387 RCL 14
388 ADV
389 "N"
390 XEQ 11
391 ADV
392 LN
393 LASTX
394 *
395 RCL 16
396 +
397 RCL 17
398 -
399 2
400 *
401 "G"
402 XEQ 11
403 STO 24
404 RCL 23
405 1
406 -
407 RCL 21
408 1
409 -
410 *
411 STO 22
412 "D.L."
413 XEQ 11
414 XEQ 10
415 RTN
416♦LBL 21
417 FS?C 02
418 LN
419 LASTX
420 *
421 ST+ 16
422 RTN
423♦LBL 22
424 LN
425 LASTX
426 *
427 ST+ 17
428 RTN
429♦LBL E
430 ?DSZ
431 STOP
432 X≠0?
433 SF 02
434 ST- 13
435 ST- IND 25
436 FS?C 02
437 LN
438 LASTX
439 *
440 ST- 16
441 GTO 20
442 .END.
```

Please use paper glue to attach listings. Adhesive tape may affect print!
Bitte Listings mit Papierleim einkleben. Klebefilme können Druck bleichen!

S.V.P. utilisez de la colle à papier pour fixer les listings. Les rubans adhésifs peuvent altérer l'impression!
Per favore usare la colla per fissare i listati. Il nastro adesivo può alterare lo stampato!

REGISTERS, STATUS, FLAGS

STAT.18

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

Registers
Datenspeicher
Registres de données
Registri

00	foLNfo	50	
	foLNft		
	Sum coL.		
	•		
	•		
05	•	55	
	•		
	•		
	•		
	•		
10	•	60	
	•		
	•		
15		65	
20	fo	70	
	d.f.		
	G		
25		75	
30	A	80	
	B		
	C		
	D		
	N		
35	A+B	85	
	C+D		
	A+C		
	B+D		
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 040 Total Reg. _____ **User Mode**

Eng ☐	Fix ☒	Sci ☐		On ☒
Deg ☐	Rad ☐	Grad ☐		Off ☐

Purpose Bedeutung Signification Scopo		Flags SET	CLEAR
00			
01	$P(X^2)$ routine	X	
02	f = 0	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
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

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

00041-90292

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HEWLETT-PACKARD

HP-41C

USERS' LIBRARY SOLUTIONS

Bar Codes

Applied statistics II

APPLIED STATISTICS II

TWO WAY ANOVA

PROGRAM REGISTERS NEEDED: 108

HEWLETT PACKARD
SOLUTION BOOK:
APPLIED STATISTICS

ROW 1 (1 : 3)

ROW 2 (4 : 11)

ROW 3 (12 : 20)

ROW 4 (21 : 27)

ROW 5 (28 : 35)

ROW 6 (36 : 42)

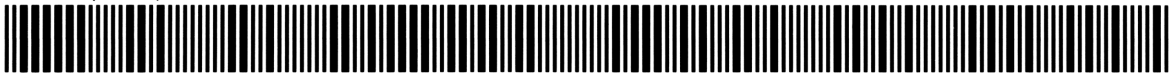
ROW 7 (42 : 50)

ROW 8 (50 : 58)

ROW 9 (59 : 64)

ROW 10 (65 : 72)

ROW 11 (73 : 81)



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ROW 13 (92 : 102)

ROW 14 (103 : 113)

ROW 15 (114 : 122)

ROW 16 (122 : 131)

ROW 17 (132 : 140)

ROW 18 (140 : 147)

ROW 19 (148 : 156)

ROW 20 (156 : 162)

ROW 21 (163 : 168)

ROW 22 (169 : 173)

ROW 23 (174 : 179)

ROW 24 (179 : 183)

ROW 25 (184 : 189)

ROW 26 (190 : 195)

ROW 27 (195 : 201)

ROW 28 (201 : 205)

ROW 29 (206 : 212)

ROW 30 (212 : 216)

ROW 31 (216 : 221)

ROW 32 (222 : 227)

ROW 33 (227 : 231)

ROW 34 (232 : 237)

ROW 35 (237 : 241)

ROW 36 (241 : 245)

ROW 37 (245 : 249)

ROW 38 (250 : 255)

ROW 39 (255 : 260)

ROW 40 (260 : 264)

ROW 41 (265 : 269)

ROW 42 (269 : 274)

ROW 43 (275 : 281)

ROW 44 (281 : 285)

ROW 45 (285 : 293)

ROW 46 (293 : 303)

ROW 47 (303 : 312)

ROW 48 (313 : 320)

ROW 49 (320 : 328)

ROW 50 (329 : 341)

ROW 51 (342 : 354)

ROW 52 (355 : 367)

ROW 53 (367 : 372)

ROW 54 (372 : 377)

ROW 55 (377 : 383)

ROW 56 (384 : 390)

ROW 57 (391 : 400)

ROW 58 (401 : 408)

ROW 59 (408 : 408)

ROW 1 (1 : 4)

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ROW 5 (29 : 36)

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ROW 9 (56 : 63)

ROW 10 (64 : 71)

ROW 11 (72 : 80)

ROW 12 (81 : 88)

ROW 13 (88 : 96)

ROW 14 (97 : 109)

ROW 15 (110 : 116)

ROW 16 (117 : 125)

ROW 17 (126 : 133)

ROW 18 (133 : 142)

ROW 19 (143 : 151)

ROW 20 (152 : 160)

ROW 21 (161 : 167)

ROW 22 (167 : 169)

ROW 23 (170 : 177)

ROW 24 (178 : 187)

ROW 25 (188 : 198)

ROW 26 (198 : 203)

ROW 27 (204 : 213)

ROW 28 (213 : 220)

ROW 29 (220 : 223)

ROW 30 (223 : 230)

ROW 31 (230 : 235)

ROW 32 (236 : 240)

ROW 33 (240 : 245)

ROW 34 (246 : 250)

ROW 35 (251 : 257)

ROW 36 (258 : 265)

ROW 37 (266 : 275)

ROW 38 (275 : 286)

ROW 39 (287 : 297)

ROW 40 (297 : 306)

ROW 41 (307 : 312)

ROW 42 (312 : 317)

ROW 43 (318 : 323)

ROW 44 (324 : 329)

ROW 45 (330 : 338)

ROW 46 (339 : 347)

ROW 47 (348 : 355)

ROW 48 (356 : 363)

ROW 1 (1 : 4)

ROW 2 (4 : 14)

ROW 3 (15 : 23)

ROW 4 (24 : 31)

ROW 5 (32 : 40)

ROW 6 (41 : 46)

ROW 7 (47 : 53)

ROW 8 (53 : 60)

ROW 9 (60 : 66)

ROW 10 (67 : 75)

ROW 11 (76 : 84)

ROW 12 (84 : 93)

ROW 13 (94 : 102)

ROW 14 (102 : 109)

ROW 15 (110 : 114)

ROW 16 (114 : 120)

ROW 17 (120 : 126)

ROW 18 (126 : 131)

ROW 19 (132 : 139)

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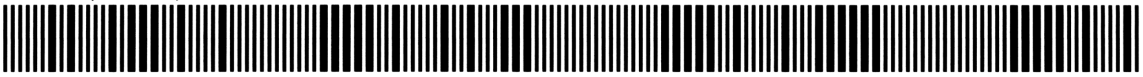
ROW 21 (150 : 162)

ROW 22 (162 : 167)

ROW 23 (168 : 173)

ROW 24 (173 : 178)



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ROW 26 (183 : 188)

ROW 27 (189 : 193)

ROW 28 (194 : 201)

ROW 29 (202 : 209)

ROW 30 (209 : 215)

ROW 31 (215 : 221)

ROW 32 (221 : 227)

ROW 33 (227 : 233)

ROW 34 (234 : 239)

ROW 35 (239 : 245)

ROW 36 (245 : 251)

ROW 37 (251 : 256)

ROW 38 (257 : 262)

ROW 39 (262 : 267)

ROW 40 (268 : 273)

ROW 41 (274 : 278)

ROW 42 (279 : 284)

ROW 43 (285 : 290)

ROW 44 (291 : 296)

ROW 45 (296 : 301)

ROW 46 (302 : 307)

ROW 47 (307 : 312)

ROW 48 (313 : 316)

ROW 49 (316 : 324)

ROW 50 (325 : 335)

ROW 51 (336 : 346)

ROW 52 (346 : 352)

ROW 53 (353 : 360)

ROW 54 (361 : 368)

ROW 55 (368 : 369)

CORRELATION COEFFICIENT

HEWLETT PACKARD
APPLIED STATISTICS

PROGRAM REGISTERS NEEDED: 91

ROW 1 (1 : 4)

ROW 2 (5 : 14)

ROW 3 (15 : 19)

ROW 4 (19 : 23)

ROW 5 (23 : 27)

ROW 6 (27 : 33)

ROW 7 (34 : 41)

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ROW 9 (47 : 51)

ROW 10 (52 : 60)

ROW 11 (61 : 67)

ROW 12 (68 : 74)

ROW 13 (74 : 81)

ROW 14 (82 : 89)

ROW 15 (89 : 100)

ROW 16 (100 : 110)

ROW 17 (110 : 119)

ROW 18 (120 : 124)

ROW 19 (124 : 134)

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ROW 21 (143 : 155)

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ROW 23 (167 : 177)

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ROW 33 (264 : 273)

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ROW 49 (395 : 398)

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ROW 9 (66 : 75)

ROW 10 (76 : 84)

ROW 11 (85 : 90)

ROW 12 (91 : 97)

ROW 13 (98 : 106)

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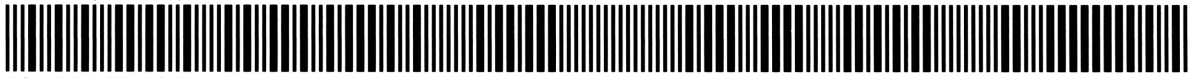

ROW 29 (197 : 202)

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ROW 62 (454 : 459)

ROW 63 (459 : 464)

ROW 64 (464 : 469)

ROW 65 (470 : 472)

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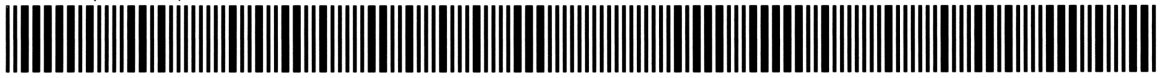

ROW 28 (156 : 160)

ROW 29 (161 : 165)

ROW 30 (165 : 170)

ROW 31 (171 : 177)

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ROW 65 (432 : 432)

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ROW 49 (392 : 401)

ROW 50 (401 : 409)

ROW 51 (409 : 416)

ROW 52 (417 : 419)

NON PARAMETRIC FREQUENCY TESTS

PROGRAM REGISTERS NEEDED: 107

HEWLETT PACKARD
SOLTUION BOOK:
APPLIED STATISTICS II

ROW 1 (1 : 5)

ROW 2 (6 : 14)

ROW 3 (15 : 24)

ROW 4 (24 : 30)

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ROW 6 (40 : 48)

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ROW 12 (76 : 84)

ROW 13 (84 : 91)

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ROW 25 (175 : 181)

ROW 26 (182 : 189)

ROW 27 (190 : 198)

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ROW 30 (216 : 226)

ROW 31 (227 : 235)

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ROW 52 (393 : 402)

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ROW 54 (411 : 414)

ROW 55 (415 : 423)

ROW 56 (424 : 433)

ROW 57 (433 : 441)

ROW 58 (441 : 442)


HEWLETT
PACKARD