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#### INTRODUCTION

Programs for your HP-65 Stat Pac 1 have been selected from the areas of general statistics, distribution functions, curve fitting and test statistics.

Each program includes a general description, formulas used in the program solution, numerical examples, and user instructions. Program listings and register allocations are given in the back of the Pac.

Some related individual programs were combined on one card when it seemed they might be useful together. In this way more programs could be included in the Pac.

We hope you find the HP-65 Stat Pac 1 a useful tool for your computational work, and welcome your comments, requests and suggestions—these are our most important source of future useroriented programs.

# FORMAT OF USER INSTRUCTIONS

The following is an example of a set of User Instructions.

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			]
2	Clear registers		A	]
3	Perform 3–4 for i=1,, n	ai	↑	]
4		b <sub>i</sub>	В	]
5			С	Answer
	(To run a new case, go to 2)			וב

To follow the instructions, start with line 1 and read from left to right, performing indicated operations as you proceed. Lines having no numbers contain special notes to the user and are inside parentheses in the INSTRUCTIONS column. The message "To run a new case, go to 2" following line 5 in the above example is a special note.

Lines are read in sequential order except where the INSTRUC-TIONS column directs otherwise. For example, "go to 2" means to jump to line 2. Repeated processes—used in most cases for a long string of input/output data—are outlined with a bold border together with a "Perform" instruction. In the above example, "Perform 3–4 for i = 1, ..., n" means to execute the loop (line 3 and line 4) n times. The first time, the dummy variable i takes the value 1; the second time i takes the value 2; etc.

Normally, as in the above example, the first instruction is "Enter program" which means load the preprogrammed magnetic card (for instructions of loading a card, see "Entering A Program" on P. 7). Some instructions are self-contained and can be carried out by just reading the INSTRUCTIONS column alone, e.g., "Enter program". But some instructions depend on the information supplied by the DATA and/or KEYS columns. In line 2 of the example above, "Clear registers" appears in the INSTRUCTIONS column and appears in the KEYS column, which means you have to clear the working registers by pressing the A key.

The DATA column specifies the input data to be supplied. Invalid arguments which result in division by zero, finding square root of a negative number, etc. will result in flashing zeros. Arguments out of the designated program range will result in incorrect answers or flashing zeros. When a computed value exceeds the calculator range, an overflow or underflow occurs and halts the program. The KEYS column specifies the keys to be pressed.  $\uparrow$  is the symbol used to denote the **ENTER+** key. All other key designations are identical to those appearing on the HP-65. Ignore any blank positions in the KEYS column.

The DISPLAY column may show counters, intermediate or final results. In line 5 of the example, the answer will be displayed after pressing the **C** key.

#### ENTERING A PROGRAM

From the card case supplied with this application pac, select a program card.

Set W/PRGM-RUN switch to RUN.

Turn the calculator ON. You should see 0.00

Gently insert the card (printed side up) in the right, lower slot as shown. When the card is part way in, the motor engages it and passes it out the left side of the calculator. Sometimes the motor engages but does not pull the card in. If this happens, push the card a little farther into the machine. Do not impede or force the card; let it move freely. (The display will flash if the card reads improperly. In this case, press  $\boxed{CLx}$  and reinsert the card.)



When the motor stops, remove the card from the left side of the calculator and insert it in the upper "window slot" on the right side of the calculator.

The program is now stored in the calculator. It remains stored until another program is entered or the calculator is turned off.



#### MEAN, STANDARD DEVIATION, STANDARD ERROR



Given a set of data points

$$\{x_1, x_2, ..., x_n\}$$

the program computes the following statistics:

mean  $\overline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$ standard deviation  $s_x = \sqrt{\frac{\sum x_i^2 - n\overline{x}^2}{n-1}}$   $\left( \text{or } s_x' = \sqrt{\frac{\sum x_i^2 - n\overline{x}^2}{n}} \right)$ standard error of the mean  $s_{\overline{x}} = \frac{s_x}{\sqrt{n}}$ 

$$\left( \text{or } s_{\overline{x}}' = \frac{s_{x}'}{\sqrt{n}} \right)$$

Notes: 1. n,  $\Sigma x_i$ ,  $\Sigma x_i^2$  are in registers  $R_1$ ,  $R_2$ ,  $R_3$ .

- To remove erroneous data, key in that data value and press E. "Σ-" is the operational inverse of "Σ+".
- 3. n is a positive integer and n > 1.
- 4. Due to roundoff errors, flashing zeros may be returned for the standard deviation when it is very small relative to the mean.

## Example:

The set of numbers {2, 3.4, 7, 11, 23, 3.41} has

$$\overline{x} = 8.30$$
  
 $s_x = 7.91$   $s_x' = 7.22$   
 $s_{\overline{x}} = 3.23$   $s_{\overline{x}}' = 2.95$ 

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		RTN R/S	]
3	Perform 3 for i = 1, 2,, n	×i		] i
	(Correct erroneous data x <sub>k</sub> )	×ĸ	E	]
4	Compute $\overline{x}$		В	] 🔻
5	Compute s <sub>x</sub>		С	] s <sub>x</sub>
	(optional)		R/S	] s <sub>x</sub> '
6	Compute $s\overline{x}$		D	] s <del>x</del>
	(optional)		R/S	] s_'
	(For a new case, go to 2)			]

# MEAN, STANDARD DEVIATION, STANDARD ERROR (GROUPED DATA)



Given a set of data points

with respective frequencies

$$f_1, f_2, ..., f_n$$

the program computes the following statistics:

mean 
$$\overline{\mathbf{x}} = \frac{\Sigma \mathbf{f}_i \mathbf{x}_i}{\Sigma \mathbf{f}_i}$$

standard deviation  $s_x = \sqrt{\frac{\Sigma f_i x_i^2 - (\Sigma f_i) \overline{x}^2}{\Sigma f_i - 1}}$ 

$$\left( \text{or } \mathbf{s_x}' = \sqrt{\frac{\Sigma f_i x_i^2 - (\Sigma f_i) \overline{x}^2}{\Sigma f_i}} \right)$$

standard error 
$$s_{\overline{x}} = \frac{s_x}{\sqrt{\Sigma f_i}}$$

$$\left( \text{or } \mathbf{s_{x}'} = \frac{\mathbf{s_{x}'}}{\sqrt{\Sigma f_{i}}} \right)$$

Notes: 1.  $\Sigma f_i$ ,  $\Sigma f_i x_i$ ,  $\Sigma f_i x_i^2$ , n are in registers  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ .

2. To remove erroneous data  $x_k$ ,  $f_k$ :

x<sub>k</sub> 🚹 f<sub>k</sub> E

" $\Sigma$ -" is the operational inverse of " $\Sigma$ +".

3. n is a positive integer and n > 1.

#### Example:

	1	2.4	7		22	2.41
xi	2	3.4	/	11	23	3.41
f <sub>i</sub>	5	3	4	2	3	1
$\overline{\mathbf{x}}$ =	7.92					
s <sub>x</sub> =	7.52	s <sub>x</sub> ' =	= 7.31			
$s_{\overline{x}} =$	1.77	$s_{x}' =$	= 1.72			

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			-
2	Initialize		RTN R/S	
3	Perform 34 for i = 1, 2,, n	xi		
4		f <sub>i</sub>	_ A	i
	(Correct erroneous data $x_k$ , $f_k$ )	×k		
		f <sub>k</sub>	E	
5	Compute $\overline{x}$		В	x
6	Compute s <sub>x</sub>		С	s <sub>x</sub>
	(optional)		R/S	s <sub>x</sub> ′
7	Compute $s_{\overline{x}}$		D	s <del>x</del>
	(optional)		R/S	s <del>x</del> ′
	(For a new case, go to 2)			

#### PERMUTATION AND COMBINATION

PERMU	ITATION AND COMBINATION	STAT 1-03A	
m <sup>P</sup> n	m <sup>c</sup> n		Ø

$${}_{m}P_{n} = \frac{m!}{(m-n)!} = m(m-1)...(m-n+1)$$

$${}_{m}C_{n} = \frac{m!}{(m-n)! n!} = \frac{m(m-1) \dots (m-n+1)}{1 \cdot 2 \cdot \dots \cdot n}$$

where m, n are integers and  $0 \le n \le m$ .

Notes: 1.  ${}_{m}P_{0} = 1$ ,  ${}_{m}P_{1} = m$ ,  ${}_{m}P_{m} = m!$ 2.  ${}_{m}C_{0} = {}_{m}C_{m} = 1$ 3.  ${}_{m}C_{1} = {}_{m}C_{m-1} = m$ 4.  ${}_{m}C_{n} = {}_{m}C_{m-n}$ 

## Examples:

- 1.  ${}_{27}P_5 = 9687600.00$
- 2.  $_{73}C_4 = 1088430.00$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute mPn	m	<u> </u>	
3		n	A	mPn
4	Compute <sub>m</sub> C <sub>n</sub>	m		•
5	•	n	В	<sub>m</sub> C <sub>n</sub>

### ARITHMETIC, GEOMETRIC, HARMONIC AND GENERALIZED MEANS

$\langle$		THMETIC, GE C AND GENEI	OMETRIC. RALIZED MEANS	S	TAT 1-04A	
	a <sub>k</sub>	Α	G	н	M(t)	

Arithmetic mean

$$\mathbf{A} = \frac{\mathbf{a}_1 + \dots + \mathbf{a}_n}{n}$$

Geometric mean

$$G = (a_1 a_2 \dots a_n)^{\frac{1}{n}}$$

Harmonic mean

$$H = \frac{n}{\frac{1}{a_1} + \frac{1}{a_2} + \dots + \frac{1}{a_n}}$$

Generalized mean

$$\mathbf{M}(t) = \left(\frac{1}{n} \sum_{k=1}^{n} \mathbf{a_k}^t\right)^{\frac{1}{t}}$$

Notes: 1.  $a_k > 0, k = 1, 2, ..., n$ 

2. 
$$M(1) = A$$
  
 $M(-1) = H$ 

### Examples:

The set of numbers {2, 3.4, 3.41, 7, 11, 23} has

A = 8.30 G = 5.87 H = 4.40

M(1) = 8.30

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize	•	RTN R/S	
3	If M(t) is desired	t	R/S	
4	Perform 4 for k=1, 2,, n	a <sub>k</sub>	A	k
5	Compute A		В	А
6	Compute G		С	G
7	Compute H		D	: н
8	Compute M(t)	· ·	E	M(t)

#### SUMS FOR TWO VARIABLES



This program computes sums for a set of given data

$$\{(x_i, y_i), i = 1, 2, ..., n\}.$$

n,  $\Sigma x_i$ ,  $\Sigma x_i^2$ ,  $\Sigma y_i$ ,  $\Sigma y_i^2$ ,  $\Sigma x_i y_i$  are in registers  $R_1$  through  $R_6$ .

This program can be used in conjunction with Stat 1-22A, Linear Regression, to fit a linear regression line or Stat 1-06A, Basic Statistic (Two Variables), to obtain means, standard deviations, covariance and correlation coefficient.

#### Example:

xi	26	30	44	50	62	68	74		
yi	92	85	78	81	54	51	40		
n = 7.00									
Σ×	<sub>i</sub> = 354	.00							
$\Sigma x_i$	$^{2} = 199$	56.00							
$\Sigma y_i = 481.00$									
$\Sigma y_i^2 = 35451.00$									
$\Sigma x_i$	y <sub>i</sub> = 222	200.00							

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		f REG	a ya anata in Net a 1 Matata 16 Matata 16
3	Perform 3–4 for i=1, 2,,n	xi	<u>↑</u>	
4		Yi	A	i i
1	(Correct erroneous data x <sub>k</sub> , y <sub>k</sub> )	×k		]
		Yk	В	]
5			C	n
6	,		R/S	]Σxi
7			R/S	$\Sigma x_i^2$
8			R/S	Σyi
9			R/S	$\Sigma \gamma_i^2$
10			R/S	$\Sigma x_i y_i$

(To run a new case, go to 2)

## BASIC STATISTICS (TWO VARIABLES)

BASIC STATISTICS (TWO VARIABLES) STAT 1-06A  
$$\overline{x}, \overline{y} = s_x \cdot s_y = s_x y = r_x y$$

This program must be used in conjunction with Stat 1-05A, Sums for Two Variables, to compute means, standard deviations, covariance and correlation coefficient derived from a set of data points

$$\{(x_i, y_i), i = 1, 2, ..., n\}$$
means  $\overline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$   $\overline{y} = \frac{1}{n} \sum_{i=1}^{n} y_i$ 
standard deviations  $s_x = \sqrt{\frac{\sum x_i^2 - n\overline{x}^2}{n-1}}$ 

$$\left( \text{or } s_x' = \sqrt{\frac{\sum x_i^2 - n\overline{x}^2}{n}} \right)$$
 $s_y = \sqrt{\frac{\sum y_i^2 - n\overline{y}^2}{n-1}}$ 

$$\left( \text{or } s_{y'} = \sqrt{\frac{\sum y_i^2 - n\overline{y}^2}{n-1}} \right)$$
covariance  $s_{xy} = \frac{1}{n-1} \left( \sum x_i y_i - \frac{1}{n} \sum x_i \sum y_i \right)$ 

$$\left( \text{or } s_{xy'} = \frac{1}{n} \left[ \sum x_i y_i - \frac{1}{n} \sum x_i \sum y_i \right] \right)$$

correlation coefficient 
$$r_{xy} = \frac{s_{xy}}{s_x s_y} = \frac{s_{xy}}{s'_x s'_y}$$

Note: n is a positive integer and n > 1.

\_

#### Example:

x <sub>i</sub>	26	30	44	50	62	68	74
y <sub>i</sub>	92	85	78	81	54	51	40
<u>x</u> =	50.57,	<del>y</del> = 6	58.71				
s <sub>x</sub> =	18.50,	$s_y =$	20.00				
s <sub>x</sub> ' =	: 17.13,	s <sub>y</sub> ' =	18.51				
S <sub>xy</sub>	= -354.2	14					
s <sub>xy</sub> ′	= -303.	55					

 $r_{xy} = -0.96$ 

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program <i>Stat 1–05A</i> Initialize		f REG	
3	Perform 3–4 for i = 1, 2,, n	×i		
4	·	Уi	A	i
	(Correct erroneous data $x_k$ , $y_k$ )	×k		
	•	Уĸ	В	]
5	Enter program Stat 1-06A			]
6	•		A	] <del>x</del>
7			R/S	] <del>v</del>
8		•	В	] s <sub>x</sub>
9			R/S	s <sub>y</sub>
	(optional)		R/S	s <sub>x</sub> '
	(optional)		R/S	] sy'
10			С	s_xy
	(optional)	•	R/S	s <sub>xy</sub> '
11	· · · · · · · · · · · · · · · · · · ·	•	D	] r <sub>xy</sub>

### MOMENTS, SKEWNESS AND KURTOSIS (FOR GROUPED OR UNGROUPED DATA)

$$\begin{array}{c|c} \hline \text{MOMENTS, SKEWNESS AND KURTOSIS} & \textbf{STAT 1-07A 1} \\ \hline \Sigma^+ & \Sigma^- & \Sigma^+(f_1) & \Sigma^-(f_1) \\ \hline \end{array} \\ \hline \\ \hline \hline \\ \hline \textbf{MOMENTS, SKEWNESS AND KURTOSIS} & \textbf{STAT 1-07A 2} \\ \hline \hline \hline \hline \hline x & m_2 & m_3 & m_4 & \gamma_1, \gamma_2 \\ \hline \hline \end{array} \\ \hline \end{array}$$

This program computes the following statistics for a set of given data  $\{x_1, x_2, ..., x_n\}$ :

$$1^{st}$$
 moment  $\overline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$ 

$$2^{nd}$$
 moment  $m_2 = \frac{1}{n} \sum x_i^2 - \overline{x}^2$ 

$$3^{rd}$$
 moment  $m_3 = \frac{1}{n} \Sigma x_i^3 - \frac{3}{n} \overline{x} \Sigma x_i^2 + 2\overline{x}^3$ 

4<sup>th</sup> moment 
$$m_4 = \frac{1}{n} \Sigma x_i^4 - \frac{4}{n} \overline{x} \Sigma x_i^3 + \frac{6}{n} \overline{x}^2 \Sigma x_i^2 - 3\overline{x}^4$$

Moment coefficient of skewness

$$\gamma_1 = \frac{m_3}{m_2^{3/2}}$$

Moment coefficient of kurtosis

$$\gamma_2 = \frac{m_4}{{m_2}^2}$$

This program also provides the option for computing those statistics for grouped data (using similar formulas as for ungrouped data):

Reference: Theory and Problems of Statistics, M. R. Spiegel, Schaum's Outline, McGraw-Hill, 1961

### Examples:

l.	Ung	roupe	d data							
	i	1	2	3	4	5	6	7	8	9
-	x <sub>i</sub>	2.1	3.5	4.2	6.5	4.1	3.6	5.3	3.7	4.9
				1.39, n	n <sub>3</sub> = (	0.39, r	n <sub>4</sub> =	5.49		
	$\gamma_1 =$	0.24	, γ <sub>2</sub> =	2.84						
2.	Gro	uped	data							
-	j y <sub>j</sub> f <sub>j</sub>	1 3 4	2 2 5	3 4 3		1				
	<u>x</u> =	3.13,	m <sub>2</sub> =	1.98, r	n <b>3</b> =	2.14,	m <sub>4</sub> =	11.05	i	
	γ <sub>1</sub> =	= 0.77	', γ <sub>2</sub> =	2.81						
LINE		INS	TRUC	TIONS		DAT	A	KEY	/S	DISPLAY
1	Ent	ter prog	gram on	card 1						
2	Init	tialize						f	REG	
3	Fo	r group	ed data	, go to 1	2			i.		
4	Per	form 4	for i=1	, <b>2</b> ,,n		×i	i .	Α		i
leta nece na		orrect e	rroneo	us data x	( <sub>k</sub> )	×	ĸ	В		
5	En	ter pro	gram or	n card 2					·	
6								Α	• • • •	, <b>x</b>
7								в		$m_2$
8								C		m <sub>3</sub>
9								D		m <sub>4</sub>
10								E		$\gamma_1$
11								R/S		$\gamma_2$
	(F	or a ne	w case,	go to 1)				i i		s a su a successo de
12	Pe	rform '	12–13	for j=1,2	!,,m	y	'i	1	111	
13	:					f	i.	С	- - 	and and an and a second se
an caranan	е исен (С	orrect	erronec	ous data '	yh, †h	)	'n	1	an arte en la della fi	
1						f	h.	D		
								•		

#### RANDOM NUMBER GENERATOR



This program calculates:

(1) Uniformly distributed random numbers u<sub>i</sub> in the range

$$0 \le u_i \le 1$$

using the following formula:

$$u_i = Fractional part of [(\pi + u_{i-1})^8]$$

Initial value  $u_0 = 0$  is used.

(2) Normally distributed random numbers  $n_i$  with mean m and standard deviation  $\sigma$ . The technique involves transforming uniform random variables to normal variables by the formulas:

$$N_{i} = (-2 \ln u_{i})^{\frac{1}{2}} \cos (2\pi u_{i+1})$$
$$N_{i+1} = (-2 \ln u_{i})^{\frac{1}{2}} \sin (2\pi u_{i+1})$$

where  $u_i$ ,  $u_{i+1}$  are independent uniform random variables,

$$0 < u_i < 1$$
.

The N<sub>i</sub> thus generated are normally distributed with mean zero and unity variance.

Numbers  $N_i$  are used to generate a more general set of normally distributed numbers with mean m and standard deviation  $\sigma$  by

$$n_{i} = \sigma N_{i} + m$$
$$n_{i+1} = \sigma N_{i+1} + m$$

Note: Two initializing uniform random numbers u<sub>a</sub>, u<sub>b</sub> must be specified by the user, such that

$$u_a \neq u_b$$
$$0 < u_a < 1$$
$$0 < u_b < 1$$

**Reference:** Handbook of Mathematical Functions, U.S. Dept. of Commerce, Applied Mathematics Series, 1964

#### Examples:

1. The following uniformly distributed pseudo random numbers are generated:

0.53, 0.52, 0.39, 0.49, 0.97, 0.29, 0.65, 0.30, 0.40, 0.06, 0.14, 0.16, 0.68, 0.22, ...

2. If m = 2,  $\sigma = 1$ ,  $u_a = 0.23$ ,  $u_b = 0.82$  then the following pseudo normal numbers are obtained:

2.73, 0.45, 2.52, 1.19, 3.51, 2.75, 1.79, 1.83, 1.00, 0.87, 1.90, 1.62, 1.74, 1.92, 1.24, 2.68, ...

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			]
2	For normal numbers, go to 5			
3	Initialize		A	
4	Perform 4 for i=1,2,3,		В	u <sub>i</sub> *
5	Store m, σ	m		
6		σ	С	
7	Store u <sub>a</sub> , u <sub>b</sub>	ua		
8		u <sub>b</sub>	D	]
9	Perform 9 for i=1,2,3,		<b>E</b>	] n <sub>i</sub>
	(Machine is set to RAD mode			
	in subroutine E)			

\*If a different sequence of numbers is desired, choose a starting value  $u_0$  such that  $0 \le u_0 \le 1$  and do:

- 1. u<sub>0</sub> STO 1
- 2. Skip step 3 and perform step 4.

# ANALYSIS OF VARIANCE (ONE WAY)

ANALYSIS OF VARIANCE (ONE WAY) STAT 1-09A  

$$\Sigma$$
+ Sum<sub>i</sub> F  $\Sigma$ -

The one-way analysis of variance tests the differences between the population means of k treatment groups. Group i (i = 1, 2, ..., k) has  $n_i$  observations (treatment group may have equal or unequal number of observations).

Sum<sub>i</sub> = sum of observations in treatment group i

$$= \sum_{j=1}^{n_i} x_{ij}$$

Total SS = 
$$\sum_{i=1}^{k} \sum_{j=1}^{n_{i}} x_{ij}^{2} - \frac{\left(\sum_{i=1}^{k} \sum_{j=1}^{n_{i}} x_{ij}\right)^{2}}{\sum_{i=1}^{k} n_{i}}$$
  
Treat SS =  $\sum_{i=1}^{k} \frac{\left(\sum_{j=1}^{n_{i}} x_{ij}\right)^{2}}{n_{i}} - \frac{\left(\sum_{i=1}^{k} \sum_{j=1}^{n_{i}} x_{ij}\right)^{2}}{\sum_{i=1}^{k} n_{i}}$ 

Error SS = Total SS – Treat SS

 $df_1 = \text{Treat } df = k - 1$  $df_2 = \text{Error } df = \sum_{i=1}^{k} n_i - k$ 

Treat MS = 
$$\frac{\text{Treat SS}}{\text{Treat df}}$$

$$\text{Error MS} = \frac{\text{Error SS}}{\text{Error df}}$$

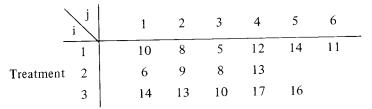
$$F = \frac{\text{Treat MS}}{\text{Error MS}} \qquad \text{(with } k - 1 \text{ and } \sum_{i=1}^{k} n_i - k \text{ degrees of freedom)}$$

Total SS, Treat SS, Error SS are in registers R1, R2, R3.

Note: Erroneous data of the current treatment group can be corrected by entering the value then pressing **D** key.

Reference: Mathematical Statistics, J.E. Freund, Prentice Hall, 1962

#### Example:



 $Sum_1 = 60.00$ 

 $Sum_2 = 36.00$ 

 $Sum_3 = 70.00$ 

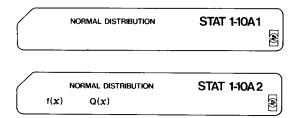
F = 3.79

 $df_1 = 2.00$ 

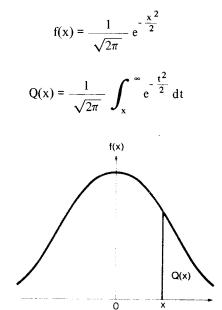
 $df_2 = 12.00$ 

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		f REC	) 
3	Perform 3–5 for i=1,2,,k	منعوش وبعد بورود در	ng ng <sup>1</sup> a a <b>ng daga s</b> a pang na sa	a a subar a subara a subara s
4	Perform 4 for j=1,2,,ni	×ij	A	
'unicon e	(Correct erroneous data x <sub>im</sub> )	x <sub>im</sub>	D	
5			В	Sumi
6	anali il i dha dama a dh'i an ann an	ing and a second second	С	F
7			R/S	df1
8			R/S	df <sub>2</sub>
	(For a paw case go to 2)			

#### NORMAL DISTRIBUTION



For a standard normal distribution



For  $x \ge 0$ , polynomial approximation is used to compute Q(x):

$$Q(x) = f(x) (b_1 t + b_2 t^2 + b_3 t^3 + b_4 t^4 + b_5 t^5) + \epsilon(x)$$

where 
$$|\epsilon(\mathbf{x})| < 7.5 \times 10^{-8}$$
  
 $t = \frac{1}{1 + rx}$ ,  $r = 0.2316419$   
 $b_1 = .31938153$ ,  $b_2 = -.356563782$   
 $b_3 = 1.781477937$ ,  $b_4 = -1.821255978$ 

 $b_5 = 1.330274429$ 

Note: f(-x) = f(x), Q(-x) = 1 - Q(x)

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

#### Examples:

- 1. f(1.18) = 0.20Q(1.18) = 0.12
- 2. f(2.28) = 0.03Q(2.28) = 0.01

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program on card 1			]
2			A	]
3	Enter program on card 2			
4	· ·	x	A	f(x)
5			В	Q(x)
	(For a new x, go to 4)			

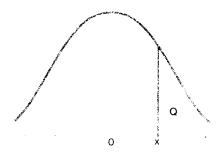
#### **INVERSE NORMAL INTEGRAL**



This program determines the value of x such that

$$Q = \int_{x}^{\infty} \frac{e^{-\frac{t^2}{2}}}{\sqrt{2\pi}} dt$$

where Q is given and  $0 < Q \le 0.5$ .



The following rational approximation is used:

$$x = t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} + \epsilon(Q)$$

where  $|\epsilon(Q)| < 4.5 \times 10^{-4}$ 

$$t = \sqrt{\ln \frac{1}{Q^2}}$$
  

$$c_0 = 2.515517 \qquad d_1 = 1.432788$$
  

$$c_1 = 0.802853 \qquad d_2 = 0.189269$$
  

$$c_2 = 0.010328 \qquad d_3 = 0.001308$$

Note: If Q > 0.5, or  $Q \le 0$ , flashing zeros will indicate the error.

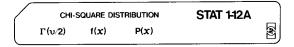
Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

### Examples:

- 1. Q = 0.12x = 1.18
- 2. Q = 0.05x = 1.65

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2			A	
3	•	Q	В	×
	(For a new Q, go to 3)			

### **CHI-SQUARE DISTRIBUTION**

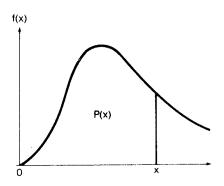


This program evaluates the chi-square density

$$f(x) = \frac{1}{2^{\frac{\nu}{2}} \Gamma\left(\frac{\nu}{2}\right)} x^{\frac{\nu}{2}-1} e^{-\frac{x}{2}}$$

where  $x \ge 0$ 

 $\nu$  is the degrees of freedom.



Series approximation is used to evaluate the cumulative distribution

$$P(x) = \int_{0}^{x} f(t) dt$$
$$= \left(\frac{x}{2}\right)^{\frac{\nu}{2}} \frac{e^{-\frac{x}{2}}}{\Gamma\left(\frac{\nu+2}{2}\right)} \left[1 + \sum_{k=1}^{\infty} \frac{x^{k}}{(\nu+2)(\nu+4)\dots(\nu+2k)}\right]$$

The program computes successive partial sums of the above series. When two consecutive partial sums are equal, the value is used as the sum of the series.

- Notes: 1. Program requires  $\nu \le 141$ . If  $\nu > 141$  and  $\nu$  is even, then display shows all 9's for  $\Gamma(\nu/2)$ ; if  $\nu > 141$  and  $\nu$  is odd, no warnings will be given, but answers are incorrect.
  - 2. If both x and  $\nu$  are large, f(x) may overflow the machine.
  - 3. If v is even,

$$\Gamma\left(\frac{\nu}{2}\right) = \left(\frac{\nu}{2} - 1\right)!$$

If v is odd,

$$\Gamma\left(\frac{\nu}{2}\right) = \left(\frac{\nu}{2} - 1\right)\left(\frac{\nu}{2} - 2\right) \cdots \left(\frac{1}{2}\right)\Gamma\left(\frac{1}{2}\right)$$
4. 
$$\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$$

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

#### **Examples:**

1. 
$$\nu = 20$$
,  $\Gamma\left(\frac{\nu}{2}\right) = 362880.00$   
 $f(9.591) = 0.02$ ,  $P(9.591) = 0.03$   
 $f(15) = 0.06$ ,  $P(15) = 0.22$   
2.  $\nu = 3$ ,  $\Gamma\left(\frac{\nu}{2}\right) = 0.89$ 

$$f(7.82) = 0.02, P(7.82) = 0.95$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		ν	A	Γ(ν/2)
3	Compute f(x) and P(x)	×	В	f(x)
4			С	P(x)
	(For a different x, go to 3.			• ··-
	For a new case, go to 2)	•		

### t **DISTRIBUTION**

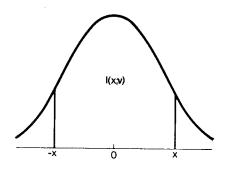


This program evaluates the integral for t distribution

$$I(x, \nu) = \int_{-x}^{x} \frac{\Gamma\left(\frac{\nu+1}{2}\right) \left(1 + \frac{y^2}{\nu}\right)^{-\frac{\nu+1}{2}}}{\sqrt{\pi\nu} \ \Gamma\left(\frac{\nu}{2}\right)} dy$$

where 
$$x > 0$$
,

 $\nu$  is the degrees of freedom.



Formulas used are:

(1)  $\nu$  even

$$I(x, \nu) = \sin \theta \left\{ 1 + \frac{1}{2} \cos^2 \theta + \frac{1 \cdot 3}{2 \cdot 4} \cos^4 \theta + \dots + \frac{1 \cdot 3 \cdot 5 \dots (\nu - 3)}{2 \cdot 4 \cdot 6 \dots (\nu - 2)} \cos^{\nu - 2} \theta \right\}$$

(2)  $\nu$  odd

$$I(x, \nu) = \begin{cases} \frac{2\theta}{\pi} & \text{if } \nu = 1\\ \frac{2\theta}{\pi} + \frac{2}{\pi}\cos\theta & \left\{\sin\theta \left[1 + \frac{2}{3}\cos^2\theta + \dots + \frac{2\cdot 4\dots(\nu-3)}{1\cdot 3\dots(\nu-2)}\cos^{\nu-3}\theta\right]\right\} & \text{if } \nu > 1 \end{cases}$$
  
where  $\theta = \tan^{-1}\left(\frac{x}{\sqrt{\nu}}\right)$ 

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

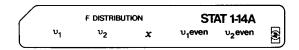
Example:

I(2.201, 11) = 0.95

I (2.75, 30) = 0.99

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		x	<b>†</b>	]
3		ν	A	] l(x, v)
	(Machine now is in RAD mode)			

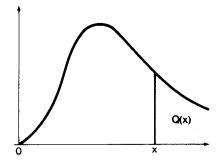
**F DISTRIBUTION** 



This program evaluates the integral of the F distribution

$$Q(x) = \int_{x}^{\infty} \frac{\Gamma\left(\frac{\nu_{1} + \nu_{2}}{2}\right) y^{\frac{\nu_{1}}{2} - 1} \left(\frac{\nu_{1}}{\nu_{2}}\right)^{\frac{\nu_{1}}{2}}}{\Gamma\left(\frac{\nu_{1}}{2}\right) \Gamma\left(\frac{\nu_{2}}{2}\right) \left(1 + \frac{\nu_{1}}{\nu_{2}}y\right)^{\frac{\nu_{1} + \nu_{2}}{2}}} dy$$

for given values of x (>0), degrees of freedoms  $\nu_1$ ,  $\nu_2$ , provided either  $\nu_1$  or  $\nu_2$  is even.



The integral is evaluated by means of the following series:

(1)  $v_1$  even

$$Q(\mathbf{x}) = t^{\frac{\nu_2}{2}} \left[ 1 + \frac{\nu_2}{2} (1 - t) + \dots + \frac{\nu_2 (\nu_2 + 2) \dots (\nu_2 + \nu_1 - 4)}{2 \cdot 4 \dots (\nu_1 - 2)} (1 - t)^{\frac{\nu_1 - 2}{2}} \right]$$

(2)  $\nu_2$  even

$$Q(\mathbf{x}) = 1 - (1 - t)^{\frac{\nu_1}{2}} \left[ 1 + \frac{\nu_1}{2} t + \dots + \frac{\nu_1(\nu_1 + 2) \dots (\nu_2 + \nu_1 - 4)}{2 \cdot 4 \dots (\nu_2 - 2)} t^{\frac{\nu_2 - 2}{2}} \right]$$

where  $t = \frac{\nu_2}{\nu_2 + \nu_1 x}$ 

Note: If both  $\nu_1$ ,  $\nu_2$  are even, the two formulas would generate identical answers. Using the smaller of  $\nu_1$ ,  $\nu_2$  could save computation time. For example, if  $\nu_1 = 10$ ,  $\nu_2 = 20$ , then classify the problem as  $\nu_1$  is even and use the **D** key to obtain the answer.

#### Examples:

- 1.  $v_1 = 7, v_2 = 6$ O (4.21) = 0.05
- 2.  $\nu_1 = 4, \ \nu_2 = 20$ Q (2.25) = 0.10

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		v <sub>1</sub>	A	
3		ν2	В	
4		×	С	]
5	If $\nu_1$ is even	i	D	Q(x)
6	If $\nu_2$ is even		E	Q(x)
	(For a new case, go to 2)			

## **BIVARIATE NORMAL DISTRIBUTION**

BIVARIATE NORMAL DISTRIBUTION STAT 1-15A  

$$\mu_1, \sigma_1 \quad \mu_2, \sigma_2 \quad \rho \quad f(x,y)$$

$$f(x,y) = \frac{1}{2\pi \sigma_1 \sigma_2 \sqrt{1-\rho^2}} e^{-P(x,y)}$$

where

$$P(x,y) = \frac{1}{2(1-\rho^2)} \left[ \frac{(x-\mu_1)^2}{\sigma_1^2} - 2\rho \ \frac{(x-\mu_1)(y-\mu_2)}{\sigma_1\sigma_2} + \frac{(y-\mu_2)^2}{\sigma_2^2} \right]$$

Notes: 1.  $\sigma_1 \neq 0, \sigma_2 \neq 0$ 

2. Program requires  $\rho^2 < 1$ .

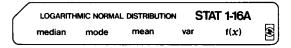
Reference: Mathematical Statistics, J.E. Freund, Prentice Hall, 1962

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 $\mu_1 = -1, \ \sigma_1 = 1.5$   $\mu_2 = 1, \ \sigma_2 = 0.5$   $\rho = 0.7$  f(1, 2) = 0.04f(-1, 1) = 0.30

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			]
2		μ1		]
3		σ1	A	
4		μ2		]
5		σ2	В	]
6		ρ	С	]
7	· · ·	×		]
8		Y	D	f(x, y)
	(For new values of x, y go to 7)			

# LOGARITHMIC NORMAL DISTRIBUTION



If X is a random variable whose logarithm is normally distributed with mean m and variance  $\sigma^2$ , then X has a logarithmic normal distribution with density function

$$f(x) = \frac{1}{x \sqrt{2\pi\sigma^2}} e^{-\frac{1}{2\sigma^2} (\ln x - m)^2}$$

where x > 0

This program computes f(x) and the following statistics for given m,  $\sigma^2$ :

Note: Program requires  $\sigma^2 \neq 0$ .

Reference: Statistical Theory and Methodology in Science and Engineering, K.A. Brownlee, John Wiley & Sons, 1965

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# Example:

m = 1,  $\sigma^2$  = 1 median = 2.72 mode = 1.00 mean = 4.48 variance = 34.51 f(.1) = 0.02 f(.6) = 0.21 f(1) = 0.24

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		m	1	]
3		σ2	A	median
4	•		В	mode
5			C	mean
6			D	variance
7	Compute f(x)	×	E	f(x)
-	(For a different x, go to 7)			

# WEIBULL DISTRIBUTION



This program can be used to find:

(1) 
$$f(x) = ab x^{b-1} exp(-ax^b)$$

where a > 0, b > 0, x > 0

(2) 
$$Q(x) = \int_{x}^{\infty} ab t^{b-1} exp(-at^{b}) dt$$
$$= exp(-ax^{b})$$

(3) x (for a given Q, 0 < Q < 1), such that

$$Q = \int_{x}^{\infty} f(t) dt$$

The following formula is used:

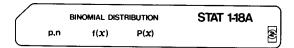
$$x = \left(\frac{\ln Q}{-a}\right)^{\frac{1}{b}}$$

#### Reference: Statistics in Research, Bernard Ostle, Iowa State University Press, 1963

- a = 0.1, b = 0.8
- 1. f(3.2) = 0.05
- 2. Q(3.2) = 0.78
- 3. If Q = 0.5, then x = 11.25

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		а	<u> </u>	
3		b	A	
4	Compute f(x), Q(x)	×	В	f(x)
5			С	Q(x)
6	Find x for a given Q	۵	D	X

# **BINOMIAL DISTRIBUTION**



This program evaluates the binomial density function for given p and n:

$$f(x) = \binom{n}{x} p^{x} (1-p)^{n-x}$$

where n is

n is a positive integer

0 and <math>x = 0, 1, 2, ..., n

The recursive relation

$$f(x + 1) = \frac{p(n - x)}{(x + 1)(1 - p)} f(x)$$
  
(x = 0, 1, 2, ..., n - 1)

is used to find the cumulative distribution

$$P(x) = \sum_{k=0}^{x} f(k)$$

The mean m and the variance  $\sigma^2$  are given by

m = np

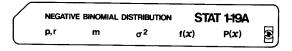
$$\sigma^2 = np (1 - p)$$

Reference: Modern Probability Theory and its Applications, E. Parzen, John Wiley & Sons, 1960

 $p = 0.49, \quad n = 6$ m = 2.94,  $\sigma^2 = 1.50$ f(4) = 0.22 P(4) = 0.90

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			]
2		p		]
3	+	n		] m
4	• · · · · · · · · · · · · · · · · · · ·		R/S	σ <sup>2</sup>
5	Compute f(x) and P(x)	×	В	f(x)
6	:		С	] P(x)
	(For a new value of x, go to 5)	;		]

# **NEGATIVE BINOMIAL DISTRIBUTION**



This program evaluates the negative binomial density function for given p and r:

$$f(x) = \begin{pmatrix} x+r-1 \\ r-1 \end{pmatrix} p^r (1-p)^x$$

where

e r is a positive integer

$$0 and  $x = 0, 1, 2, ...$$$

The recursive relation

$$f(x + 1) = \frac{(1 - p)(x + r)}{x + 1} f(x)$$

is used to find the cumulative distribution

$$P(x) = \sum_{k=0}^{x} f(k)$$

The mean m and the variance  $\sigma^2$  are given by

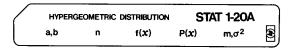
$$m = \frac{r(1-p)}{p}$$
$$\sigma^2 = \frac{r(1-p)}{p^2}$$

- Note: If we interpret p as the probability of success of a given event, then f(x) is the probability that exactly x + r trials will be required to get r successes.
- Reference: Modern Probability Theory and its Applications, E. Parzen, John Wiley & Sons, 1960

p = 0.9, r = 4 m = 0.44  $\sigma^2$  = 0.49 f(1) = 0.26 P(1) = 0.92 f(2) = 0.07 P(2) = 0.98

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Enter p, r	р		]
3		r	A	
4	Compute mean m		В	] m
5	Compute variance $\sigma^2$		С	$\sigma^2$
6	Compute f(x), P(x)	×		f(x)
7			E	P(x)
	(For a different x, go to 6)			

# HYPERGEOMETRIC DISTRIBUTION



This program evaluates the hypergeometric density function for given a, b and n:

$$f(x) = \frac{\begin{pmatrix} a \\ x \end{pmatrix} \begin{pmatrix} b \\ n-x \end{pmatrix}}{\begin{pmatrix} a+b \\ n \end{pmatrix}}$$

where a, b, n are positive integers  $x \le a, n - x \le b$  and x = 0, 1, 2, ..., n

The recursive relation

$$f(x + 1) = \frac{(x - a)(x - n)}{(x + 1)(b - n + x + 1)} f(x)$$
  
(x = 0, 1, 2, ..., n - 1)

is used to find the cumulative distribution

$$P(x) = \sum_{k=0}^{x} f(k)$$

The mean m and the variance  $\sigma^2$  are given by

2

$$m = \frac{an}{a+b}$$
$$= \frac{abn(a+b-n)}{abn(a+b-n)}$$

$$\sigma^2 = \frac{1}{(a+b)^2 (a+b-1)}$$

Notes: 1. f(0) = P(0)

- 2. When x is large, due to round-off error, the computed value for P(x) might be slightly greater than one. In that case, let P(x) = 1.
- 3. This program requires  $a + b \le 69$ .

Reference: Mathematical Statistics, J.E. Freund, Prentice Hall, 1962

Given a = 8, b = 12, n = 6, then f(0) = P(0) = 0.02 f(3) = 0.32, P(3) = 0.86 f(5) = 0.02, P(5) = 1.00 m = 2.40 $\sigma^2 = 1.06$ 

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			]
2		a		]
3		b	<b>A</b>	
4		n	В	f(0)
5	For x ≥ 1	×	<b>C</b>	f(x)
6	· · · · · · · · · · · · · · · · · · ·		D	P(x)
	(For a new value of x, go to 5.			]
	For a new n, go to 4.			
	For different a, b, go to 2)			]
7	Compute m, $\sigma^2$		E	m
8			R/S	σ²

#### POISSON DISTRIBUTION

P	DISSON DIST	RIBUTION	STAT 1-21A	
λ	f(x)	P(x)		

Density function

$$f(x) = \frac{\lambda^x e^{-\lambda}}{x!}$$

where

x = 0, 1, 2, ...

 $\lambda > 0$ 

Cumulative distribution

$$P(x) = \sum_{k=0}^{x} f(k)$$

This program evaluates f(x) and P(x) for a given  $\lambda$  using the recursive relation

$$f(x+1) = \frac{\lambda}{x+1} f(x)$$

Note: Mean = variance =  $\lambda$ 

#### Example:

 $\lambda = 3.2$ f(0) = 0.04 f(7) = 0.03 P(7) = 0.98

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		λ	<b>A</b>	f(0)
3	Compute f(x) and P(x)	x	В	f(x)
4			С	P(x)
	(For new value of x, go to 3.			
	For new value of $\lambda$ , go to 2)			

#### LINEAR REGRESSION



This program must be used in conjunction with Stat 1-05A, Sums for Two Variables, to fit a straight line

 $y = a_0 + a_1 x$ 

to a set of data points  $\{(x_i, y_i), i = 1, 2, ..., n\}$  by the least squares method.

The program computes:

1. regression coefficients  $a_0$ ,  $a_1$ 

$$a_{1} = \frac{\sum x_{i}y_{i} - \frac{\sum x_{i}\sum y_{i}}{n}}{\sum x_{i}^{2} - \frac{(\sum x_{i})^{2}}{n}}$$
$$a_{0} = \overline{y} - a_{1}\overline{x}$$

where

$$\overline{\mathbf{x}} = \frac{\Sigma \mathbf{x}_i}{n}$$
$$\overline{\mathbf{y}} = \frac{\Sigma \mathbf{y}_i}{n}$$

2. coefficient of determination

$$r^{2} = \frac{\left[\Sigma x_{i}y_{i} - \frac{\Sigma x_{i}\Sigma y_{i}}{n}\right]^{2}}{\left[\Sigma x_{i}^{2} - \frac{(\Sigma x_{i})^{2}}{n}\right]\left[\Sigma y_{i}^{2} - \frac{(\Sigma y_{i})^{2}}{n}\right]}$$

 $r^2$  can be interpreted as the proportion of total variation about the mean  $\overline{y}$  explained by the regression. In other words,  $r^2$ measures the "goodness of fit" of the regression line. Note that  $0 \le r^2 \le 1$ , and if  $r^2 = 1$ , we have a perfect fit. 3. estimated value  $\hat{y}$  on the regression line for any given x

 $\hat{\mathbf{y}} = \mathbf{a_0} + \mathbf{a_1} \mathbf{x}$ 

4. standard error of estimate of y on x

$$s_{y \cdot x} = \sqrt{\frac{\Sigma(y_i - \hat{y}_i)^2}{n - 2}}$$
$$= \sqrt{\frac{\Sigma y_i^2 - a_0 \Sigma y_i - a_1 \Sigma x_i y_i}{n - 2}}$$

5. standard error of the regression coefficient  $a_0$ 

$$s_0 = s_{y-x} \sqrt{\frac{\Sigma x_i^2}{n \left[\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n}\right]}}$$

6. standard error of the regression coefficient a<sub>1</sub>

$$s_1 = \frac{s_{y \cdot x}}{\sqrt{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n}}}$$

Note: n is a positive integer and  $n \neq 1$  or 2.

#### **References:**

Applied Regression Analysis, Draper and Smith, John Wiley & Sons, 1966

Statistics in Research, B. Ostle, Iowa State University Press, 1963

x <sub>i</sub>	26	30	44	50	62	68	74
Yi	92	85	78	81	54	51	74 40

1.  $a_0 = 121.04$  $a_1 = -1.03$ 

Regression line is y = 121.04 - 1.03x

- 2.  $r^2 = 0.92$
- 3. For x = 80,  $\hat{y} = 38.27$
- 4.  $s_{y \cdot x} = 6.34$
- 5.  $s_0 = 7.47$  $s_1 = 0.14$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program Stat 1-05A			
2	Initialize		f REG	
3	Perform 3—4 for i = 1, 2,, n	×i		
4		Yi		i
	(Correct erroneous data x <sub>k</sub> , y <sub>k</sub> )	×k		
		٧k	В	
5	Enter program Stat 1–22A			
6			<b>A</b>	ao
7			R/S	aı
8			B	r <sup>2</sup>
9		×	с	Ŷ
	(For a new x, go to 9)			]
10			D	] s <sub>γ·×</sub>
11			E	] s <sub>0</sub>
12			R/S	] s <sub>1</sub>

#### **EXPONENTIAL CURVE FIT**



This program computes the least squares fit of n pairs of data points  $\{(x_i, y_i), i = 1, 2, ..., n\}$ , where  $y_i > 0$ , for an exponential function of the form

$$y = a e^{bx}$$
 (a > 0)

The equation is linearized into

The following statistics are computed:

1. Coefficients a, b

$$b = \frac{\sum x_i \ln y_i - \frac{1}{n} (\sum x_i) (\sum \ln y_i)}{\sum x_i^2 - \frac{1}{n} (\sum x_i)^2}$$
$$a = \exp\left[\frac{\sum \ln y_i}{n} - b \frac{\sum x_i}{n}\right]$$

2. Coefficient of determination

$$r^{2} = \frac{\left[\sum x_{i} \ln y_{i} - \frac{1}{n} \sum x_{i} \sum \ln y_{i}\right]^{2}}{\left[\sum x_{i}^{2} - \frac{(\sum x_{i})^{2}}{n}\right] \left[\sum (\ln y_{i})^{2} - \frac{(\sum \ln y_{i})^{2}}{n}\right]}$$

3. Estimated value ŷ for a given x

$$\hat{y} = a e^{bx}$$

Note: n is a positive integer and  $n \neq 1$ .

Reference: Statistical Theory and Methodology in Science and Engineering, K.A. Brownlee, John Wiley & Sons, 1965

x <sub>i</sub>	.72	1.31	1.95	2.58	3.14
yi	2.16	1.61	1.16	.85	0.5

- 1. a = 3.45, b = -0.58 $y = 3.45 e^{-0.58x}$
- 2.  $r^2 = 0.98$
- 3. For x = 1.5,  $\hat{y} = 1.44$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		f REG	
3	Perform 34 for i=1, 2,, n	×i		
4	•	Yi	A	i
5			В	а
6			R/S	b
7			С	r <sup>2</sup>
8	Compute estimated value $\hat{y}$	x	D	Ŷ
	(For a new x, go to 8)			





This program fits a power curve

$$y = ax^b \qquad (a > 0)$$

to a set of data points

$$\{(\mathbf{x}_i, \mathbf{y}_i), i = 1, 2, ..., n\}$$

where  $x_i > 0$ ,  $y_i > 0$ .

By writing this equation as

$$\ln y = b \ln x + \ln a$$

the problem can be solved as a linear regression problem.

Output statistics are:

1. Regression coefficients

$$b = \frac{\sum (\ln^{l} x_{i}) (\ln y_{i}) - \frac{(\sum \ln x_{i}) (\sum \ln y_{i})}{n}}{\sum (\ln x_{i})^{2} - \frac{(\sum \ln x_{i})^{2}}{n}}$$
$$a = \exp \left[\frac{\sum \ln y_{i}}{n} - b \frac{\sum \ln x_{i}}{n}\right]$$

2. Coefficient of determination

$$r^{2} = \frac{\left[\Sigma (\ln x_{i}) (\ln y_{i}) - \frac{(\Sigma \ln x_{i}) (\Sigma \ln y_{i})}{n}\right]^{2}}{\left[\Sigma (\ln x_{i})^{2} - \frac{(\Sigma \ln x_{i})^{2}}{n}\right] \left[\Sigma (\ln y_{i})^{2} - \frac{(\Sigma \ln y_{i})^{2}}{n}\right]}$$

3. Estimated value  $\hat{y}$  for given x

$$\hat{y} = ax^{b}$$

Note: n is a positive integer and  $n \neq 1$ .

Reference: Statistical Theory and Methodology in Science and Engineering, K.A. Brownlee, John Wiley & Sons, 1965

#### Example:

x <sub>i</sub>	10	12	15	17	20	22	25	27	30	32	35	
yi	.95	1.05	1.25	1.41	1.73	2.00	2.53	2.98	3.85	4.59	6.02	

1. 
$$a = 0.03$$
,  $b = 1.46$   
 $y = 0.03x^{1.46}$ 

2. 
$$r^2 = 0.94$$

3. For x = 18, 
$$\hat{y} = 1.76$$
  
x = 23,  $\hat{y} = 2.52$ 

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		f REG	
3	Perform 3-4 for i=1, 2,, n	x <sub>i</sub>		
4		Yi	A	i
5			В	а
6			R/S	b
7			С	r <sup>2</sup>
8	Compute estimated value $\hat{\mathbf{y}}$	×	D	ŷ
	(For a new x, go to 8)			

# LOGARITHMIC CURVE FIT



This program fits a logarithmic curve

to a set of data points

$$\{(x_i, y_i), i = 1, 2, ..., n\}$$

where

$$x_i > 0.$$

Program computes:

1. Regression coefficients

$$b = \frac{\sum y_i \ln x_i - \frac{1}{n} \sum \ln x_i \sum y_i}{\sum (\ln x_i)^2 - \frac{1}{n} (\sum \ln x_i)^2}$$
$$a = \frac{1}{n} (\sum y_i - b \sum \ln x_i)$$

2. Coefficient of determination

$$r^{2} = \frac{\left[\Sigma y_{i} \ln x_{i} - \frac{1}{n} \Sigma \ln x_{i} \Sigma y_{i}\right]^{2}}{\left[\Sigma (\ln x_{i})^{2} - \frac{1}{n} (\Sigma \ln x_{i})^{2}\right] \left[\Sigma y_{i}^{2} - \frac{1}{n} (\Sigma y_{i})^{2}\right]}$$

3. Estimated value ŷ for given x

$$\hat{y} = a + b \ln x$$

Note: n is a positive integer and  $n \neq 1$ .

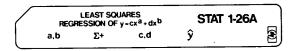
x <sub>i</sub>	3	4	6	10	12
y <sub>i</sub>	1.5	9.3	23.4	45.8	60.1

1. 
$$a = -47.02$$
,  $b = 41.39$   
 $y = -47.02 + 41.39 \ln x$ 

- 2.  $r^2 = 0.98$
- 3. For x = 8,  $\hat{y} = 39.06$ For x = 14.5,  $\hat{y} = 63.67$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		f REG	
3	Perform 3–4 for i≃1, 2,, n	xi		
4		Уi	A	i
5			В	а
6			R/S	ь
7			С	r <sup>2</sup>
8	Compute estimated value $\hat{v}$	×	D	Ŷ
	(For a new x, go to 8)			

# LEAST SQUARES REGRESSION OF y = cx<sup>a</sup> + dx<sup>b</sup>



This program determines the coefficients c, d of the equation

$$y = cx^a + dx^b$$

for a set of data points

$$\{(x_i, y_i), i = 1, 2, ..., n\}$$

where a, b are any given real numbers.

$$d = \frac{(\Sigma x_i^{2a}) (\Sigma x_i^{b} y_i) - (\Sigma x_i^{a} y_i) (\Sigma x_i^{a+b})}{(\Sigma x_i^{2b}) (\Sigma x_i^{2a}) - (\Sigma x_i^{a+b})^2}$$
$$c = \frac{\Sigma x_i^{a} y_i - d\Sigma x_i^{a+b}}{\Sigma x_i^{2a}}$$

where  $x_i > 0$  for i = 1, 2, ..., n.

**Note:** n is a positive integer and  $n \neq 1$ .

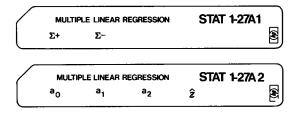
c = 10.00, d = -1.00

Regression line is  $y = 10x^{\frac{1}{2}} - x^3$ 

For x = 6,  $\hat{y} = -191.51$ 

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		f REG	
3		a		
4		b		
5	Perform 56 for i=1, 2,, n	xi		
6		Yi	В	
7			<b>C</b>	с
8			R/S	d
9	Compute estimated value $\hat{\gamma}$ on	×	D	Ŷ
	the line			
	(For a new x, go to 9)			]

#### MULTIPLE LINEAR REGRESSION



For a set of data points  $\{(x_i, y_i, z_i), i = 1, 2, ..., n\}$  this program fits a linear equation of the form

 $z = a_0 + a_1 x + a_2 y$ 

by the least squares method.

Regression coefficients  $a_0$ ,  $a_1$ ,  $a_2$  can be found by solving the normal equations:

$$\begin{aligned} & \Sigma z_{i} = a_{0} n + a_{1} \Sigma x_{i} + a_{2} \Sigma y_{i} \\ & \Sigma x_{i} z_{i} = a_{0} \Sigma x_{i} + a_{1} \Sigma x_{i}^{2} + a_{2} \Sigma x_{i} y_{i} \\ & \Sigma y_{i} z_{i} = a_{0} \Sigma y_{i} + a_{1} \Sigma x_{i} y_{i} + a_{2} \Sigma y_{i}^{2} \end{aligned} \qquad i = 1, 2, ..., n$$

$$a_{2} = \frac{A - B}{[n\Sigma x_{i}^{2} - (\Sigma x_{i})^{2}] [n\Sigma y_{i}^{2} - (\Sigma y_{i})^{2}] - [n\Sigma x_{i}y_{i} - (\Sigma x_{i}) (\Sigma y_{i})]^{2}}$$

where

$$A = [n\Sigma x_i^2 - (\Sigma x_i)^2] [n\Sigma y_i z_i - (\Sigma y_i) (\Sigma z_i)]$$

$$B = [n\Sigma x_i y_i - (\Sigma x_i) (\Sigma y_i)] [n\Sigma x_i z_i - (\Sigma x_i) (\Sigma z_i)]$$

$$a_1 = \frac{[n\Sigma x_i z_i - (\Sigma x_i) (\Sigma z_i)] - a_2 [n\Sigma x_i y_i - (\Sigma x_i) (\Sigma y_i)]}{n\Sigma x_i^2 - (\Sigma x_i)^2}$$

$$a_0 = \frac{1}{n} (\Sigma z_i - a_2 \Sigma y_i - a_1 \Sigma x_i)$$

Notes: 1. ∑x<sub>i</sub>y<sub>i</sub>, ∑x<sub>i</sub>z<sub>i</sub>, ∑y<sub>i</sub>z<sub>i</sub>, ∑y<sub>i</sub><sup>2</sup>, n, ∑x<sub>i</sub><sup>2</sup>, ∑x<sub>i</sub>, ∑y<sub>i</sub>, ∑z<sub>i</sub> are in storage registers R<sub>1</sub> through R<sub>9</sub> before program on card 2 is executed. Recall and record these sums if desired when instructions indicate to do so.

- 2. Erroneous data  $x_k$ ,  $y_k$ ,  $z_k$  can be removed by the following keystrokes:  $x_k \uparrow y_k \uparrow z_k B$
- 3. n is a positive integer and  $n \neq 1$ .

Reference: Introduction to the Theory of Statistics, Mood and Graybill, McGraw-Hill, 1963

Example:

Exan	nple:				1	
<u>\</u> i	1	2	3		$\Sigma x_i y_i = 17.57$	$\Sigma x_i = 6.55$
xi	1.5	0.45	1.8	2.8	$\Sigma x_i z_i = 38.65$	$\Sigma y_i = 9.10$
Уi	0.7	2.3	1.6	4.5	$\Sigma y_i z_i = 59.53$	$\Sigma z_i = 19.60$
zi	2.1	4.0	<b>4</b> .1	9.4	$\Sigma y_i^2 = 28.59$	$a_0 = -0.10$
	ession l		v ± 1 6	217	n = 4.00	$a_1 = 0.79$
z = -0.10 + 0.79x + 1.63y For x = 2, y = 3, $\hat{z} = 6.37$					$\Sigma x_i^2 = 13.53$	$a_2 = 1.63$
For	x = 2, y	z = 3, z =	= 6.37		$2x_i^2 = 13.33$	$a_2 = 1.03$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program on card 1			
2	Initialize		f REG	
3	Perform 3-5 for i=1, 2,, n	×i		
4		Yi		
5		zi		i
	(Correct erroneous data	×k		
	x <sub>k</sub> , y <sub>k</sub> , z <sub>k</sub> )	Yk		
		z <sub>k</sub>	В	
6	Recall and record sums		RCL 1	Σx <sub>i</sub> y <sub>i</sub>
7			RCL 2	Σxizi
8			RCL 3	] Σy <sub>i</sub> z <sub>i</sub>
9			RCL 4	] Σyi²
10			RCL 5	] <u>n</u>
11			RCL 6	] Σx <sub>i</sub> <sup>2</sup>
12			RCL 7	] Σ×i
13			RCL 8	] Σγ <sub>i</sub>
14			RCL 9	]Σzi
15	Enter program on card 2			]
16				] a <sub>0</sub>
17			В	] a <sub>1</sub>
18				] a <sub>2</sub>
19	Obtain estimated value $\hat{z}$ on the	×		]
20	line (for new values, go to 19)	У	D	] <u> </u>

#### PARABOLIC CURVE FIT

P	ARABOLIC CU	RVE FIT	STAT 1-28A	
Σ+	Σ-	ŷ		

For a set of data points  $\{(x_i, y_i), i = 1, 2, ..., n\}$  this program fits a parabola

$$y = a_0 + a_1 x + a_2 x^2$$

This program must be used in conjunction with Stat 1-27A, Multiple Linear Regression, to compute:

1. Regression coefficients

$$a_{2} = \frac{A - B}{[n \sum x_{i}^{2} - (\sum x_{i})^{2}] [n \sum x_{i}^{4} - (\sum x_{i}^{2})^{2}] - [n \sum x_{i}^{3} - (\sum x_{i})(\sum x_{i}^{2})]^{2}}$$
  
where  
$$A = [n \sum x_{i}^{2} - (\sum x_{i})^{2}] [n \sum x_{i}^{2} y_{i} - (\sum x_{i}^{2})(\sum y_{i})]$$
$$B = [n \sum x_{i}^{3} - (\sum x_{i})(\sum x_{i}^{2})] [n \sum x_{i} y_{i} - (\sum x_{i})(\sum y_{i})]$$
$$a_{1} = \frac{[n \sum x_{i} y_{i} - (\sum x_{i})(\sum y_{i})] - a_{2} [n \sum x_{i}^{3} - (\sum x_{i})(\sum x_{i}^{2})]}{n \sum x_{i}^{2} - (\sum x_{i})^{2}}$$
$$a_{0} = \frac{1}{n} (\sum y_{i} - a_{2} \sum x_{i}^{2} - a_{1} \sum x_{i})$$

2. Estimated value ŷ for given x

$$\hat{y} = a_0 + a_1 x + a_2 x^2$$

Note: n is a positive integer and  $n \neq 1$ .

# Reference: Introduction to the Theory of Statistics, Mood and Graybill, McGraw Hill, 1963

x <sub>i</sub>	0	1	1.5	3	5
y <sub>i</sub>	2.1	2	-5	-24.5	-80

1.  $\Sigma x_i^3 = 156.38$ ,  $\Sigma x_i y_i = -479.00$ ,  $\Sigma x_i^2 y_i = -2229.75$  $\Sigma x_i^4 = 712.06$ , n = 5.00,  $\Sigma x_i^2 = 37.25$  $\Sigma x_i = 10.50$ ,  $\Sigma y_i = -105.40$ 

2.  $a_0 = 2.28$ ,  $a_1 = 1.85$ ,  $a_2 = -3.66$  $y = 2.28 + 1.85 x - 3.66 x^2$ 

3. For 
$$x = 4$$
,  $\hat{y} = -48.83$ 

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program Stat 1–28A			
2	Initialize		f REG	
3	Perform 3–4 for i=1, 2,, n	×i		
4		Yi	A	i
	(Correct erroneous data x <sub>k</sub> , y <sub>k</sub> )	×ĸ		
		Yk	В	
5	Recall and record sums		RCL 1	Σx <sub>i</sub> <sup>3</sup>
6			RCL 2	Σ× <sub>i</sub> y <sub>i</sub>
7			RCL 3	Σx <sub>i</sub> ²y <sub>i</sub>
8			RCL 4	Σx <sub>i</sub> <sup>4</sup>
9			RCL 5	n
10			RCL 6	Σx <sub>i</sub> <sup>2</sup>
11			RCL 7	Σx <sub>i</sub>
12			RCL 9	Σγį
13	Enter program Stat 1-27A2			
14			A	ao
15			В	a <sub>1</sub>
16			C	a <sub>2</sub>
17	Enter program Stat 1–28A			
18	Compute estimated value $\hat{\mathbf{y}}$	×	C	Ŷ
	(For a new x, go to 18)			

# **PAIRED t STATISTIC**

	PAIRED t ST	ATISTIC	ST	AT 1-29A	
INIT	Σ+	D, s <sub>D</sub>	t,df	Σ-	8

Given a set of paired observations from two normal populations with means  $\mu_1, \mu_2$  (unknown)

let

$$D_{i} = x_{i} - y_{i}$$

$$\overline{D} = \frac{1}{n} \sum_{i=1}^{n} D_{i}$$

$$s_{D} = \sqrt{\frac{\Sigma D_{i}^{2} - \frac{1}{n} (\Sigma D_{i})^{2}}{n - 1}}$$

$$s_{\overline{D}} = \frac{s_{D}}{\sqrt{n}}$$

The test statistic

$$t = \frac{\overline{D}}{s\overline{D}}$$

which has n-1 degrees of freedom (df) can be used to test the null hypothesis

$$\mathbf{H_0}: \ \boldsymbol{\mu_1} = \boldsymbol{\mu_2}$$

Reference: Statistics in Research, B. Ostle, Iowa State University Press, 1963

xi	14	17.5	17	17.5	15.4
y <sub>i</sub>	17	20.7	21.6	20.9	17.2
$\overline{D} = c$ $s_D = c$ $t = c$ $df = c$	1.00 -7.16				

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program	1		
2	Initialize		A	
3	Perform 3-4 for i=1, 2,, n	×i		
4		Yi	В	i
	(Correct erroneous data x <sub>k</sub> , y <sub>k</sub> )	×k		
		Yk	E	
5			С	D
6			R/S	\$ <sub>D</sub>
7			D	t
8			R/S	df

#### t STATISTIC FOR TWO MEANS

t STATISTIC FOR TWO MEANS			STAT 1-30A		_)
INIT	Σ+	D	t, df	Σ-	S

Suppose  $\{x_1, x_2, ..., x_{n_1}\}$  and  $\{y_1, y_2, ..., y_{n_2}\}$  are independent random samples from two normal populations having means  $\mu_1, \mu_2$  (unknown) and the same unknown variance  $\sigma^2$ .

We want to test the null hypothesis

$$H_0: \mu_1 - \mu_2 = D$$

Define

$$\overline{x} = \frac{1}{n_1} \sum_{i=1}^{n_1} x_i$$

$$\overline{y} = \frac{1}{n_2} \sum_{i=1}^{n_2} y_i$$

$$t = \frac{\overline{x} - \overline{y} - D}{\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \sqrt{\frac{\Sigma x_i^2 - n_1 \overline{x}^2 + \Sigma y_i^2 - n_2 \overline{y}^2}{n_1 + n_2 - 2}}$$

We can use this t statistic which has the t distribution with  $n_1 + n_2 - 2$  degrees of freedom (df) to test the null hypothesis H<sub>0</sub>.

Note:  $n_2$ ,  $\Sigma y_i$ ,  $\Sigma y_i^2$ ,  $n_1$ ,  $\Sigma x_i$ ,  $\Sigma x_i^2$  are in registers  $R_1$  through  $R_6$ .

Reference: Statistical Theory and Methodology in Science and Engineering, K. A. Brownlee, John Wiley & Sons, 1965

x: 79, 84, 108, 114, 120, 103, 122, 120 y: 91, 103, 90, 113, 108, 87, 100, 80, 99, 54  $n_1 = 8$  $n_2 = 10$ 

If D = 0 (i.e., H<sub>0</sub>:  $\mu_1 = \mu_2$ ) then t = 1.73, df = 16.00

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize			
3	Perform 3 for i=1, 2,, n <sub>1</sub>	×i	В	i
	(Correct erroneous data x <sub>k</sub> )	×k	E	
4		D	C R/S	
5	Perform 5 for j=1, 2,, n <sub>2</sub>	Yj	В.	j
	(Correct erroneous data y <sub>h</sub> )	Уh	E	
6			D	t
7			R/S	df
	(For a different value of D)	D	С	
			D	] t
			R/S	df

# **CHI-SQUARE EVALUATION**

CHI-SQUARE EVALUATION STAT 1-31A 
$$O_i, E_i \quad \Sigma^- \quad O_i \quad \Sigma^-(O_i) \quad \chi^2$$

This program calculates the value of the  $\chi^2$  statistic for the goodness of fit test by the equation

$$\chi^{2} = \sum_{i=1}^{n} \frac{(O_{i} - E_{i})^{2}}{E_{i}}$$

where  $O_i =$  observed frequency

 $E_i$  = expected frequency

If the expected values are equal

$$\left(E = E_i = \frac{\Sigma O_i}{n} \text{ for all } i\right)$$

then

$$\chi^2 = \frac{n\Sigma O_i^2}{\Sigma O_i} - \Sigma O_i$$

Note: In order to apply the goodness of fit test to a set of given data, combining some classes may be necessary to make sure that each expected frequency is not too small (say, not less than 5).

Reference: Mathematical Statistics, J. E. Freund, Prentice Hall, 1962

**Examples:** 

1. 
$$O_i$$
 8 50 47 56 5 14  
 $E_i$  9.6 46.75 51.85 54.4 8.25 9.15  
 $\chi^2 = 4.84$ 

2. The following table shows the observed frequencies in tossing a die 120 times.  $\chi^2$  can be used to test if the die is fair.

Note: Assume that the expected frequencies are equal.

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		RTN R/S	
3	For equal expected values,			
	go to 7.			
4	Perform 4-5 for i = 1, 2,, n	Oi		
5		Ei		i
	(Correct erroneous data O <sub>k</sub> , E <sub>k</sub> )	Ok		
		Ek	В	
6			E	χ <sup>2</sup>
	(For a new case, go to 2)			
7	Perform 7 for i = 1, 2,, n	Oi	С	i
	(Correct erroneous data O <sub>h</sub> )	Oh	D	
8			f SF 1	
9			E	x <sup>2</sup>
10			R/S	E
	(For a new case, go to 2)			

#### 2 x k CONTINGENCY TABLE

/	2×K CONTINGENCY TABLE			STAT 1-32A		
	INIT	a <sub>i</sub> ,b <sub>i</sub>	х <sup>2</sup>	df	с	8

Contingency tables can be used to test the null hypothesis that two variables are independent.

	1	2	3	 k	Totals
Α	a <sub>1</sub>	a2	a <sub>3</sub>	 a <sub>k</sub>	. N <sub>A</sub>
В	b <sub>1</sub>	b <sub>2</sub>	b3	 b <sub>k</sub>	NB
Totals	N <sub>1</sub>	$N_2$	N <sub>3</sub>	 N <sub>k</sub>	Ν

Test statistic

$$\chi^{2} = \frac{N}{N_{A}} \sum_{i=1}^{k} \frac{a_{i}^{2}}{N_{i}} + \frac{N}{N_{B}} \sum_{i=1}^{k} \frac{b_{i}^{2}}{N_{i}} - N$$

Degrees of freedom df = k - 1

Pearson's coefficient of contingency C measures the degree of association between the two variables

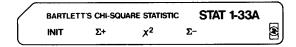
$$C = \sqrt{\frac{\chi^2}{N + \chi^2}}$$

Reference: Statistics in Research, B. Ostle, Iowa State University Press, 1963

	1	2	3		
A	2	5	4		
В	3	8	7		
df =	$\chi^2 = 0.02$ df = 2.00 C = 0.03				

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Initialize		A	
3	Perform 3-4 for i=1, 2,, k	a <sub>i</sub>	<b>↑</b>	
4		bi	В	i
5				χ <sup>2</sup>
6			D	] df
7			E	] C

# BARTLETT'S CHI-SQUARE STATISTIC



$$\chi^{2} = \frac{f \ln s^{2} - \sum_{i=1}^{k} f_{i} \ln s_{i}^{2}}{1 + \frac{1}{3(k-1)} \left[ \left( \sum_{i=1}^{k} \frac{1}{f_{i}} \right) - \frac{1}{f} \right]}$$

where  $s_i^2$  = sample variance of the i<sup>th</sup> sample  $f_i$  = degrees of freedom associated with  $s_i^2$  i = 1, 2, ..., kk = number of samples

$$s^{2} = \frac{\sum_{i=1}^{k} f_{i} s_{i}^{2}}{f}$$
$$f = \sum_{i=1}^{k} f_{i}$$

This  $\chi^2$  has a chi-square distribution (approximately) with k - 1 degrees of freedom which can be used to test the null hypothesis that  $s_1^2$ ,  $s_2^2$ , ...,  $s_k^2$  are all estimates of the same population variance  $\sigma^2$ ; i.e.

H<sub>0</sub>: Each of  $s_1^2$ ,  $s_2^2$ , ...,  $s_k^2$  is an estimate of  $\sigma^2$ .

Note: Erroneous data can be corrected by using the D key.

Reference: Statistical Theory with Engineering Applications, A. Hald, John Wiley and Sons, 1960

,

#### Example:

i	1	2	3	4	5	6
s <sub>i</sub> <sup>2</sup>	5.5	5.1	5.2	4.7	4.8	4.3
si <sup>2</sup> fi	10	20	17	1 <b>-</b> 8	8	15
χ <sup>2</sup> =	= 0.25 = 5.00					

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			]
2	Initialize		A	]
3	Perform 3–4 for i=1, 2,, k	si <sup>2</sup>		]
4		fi	В	]i
	(Correct erroneous data sm <sup>2</sup> , fm)	sm <sup>2</sup>		]
		fm	D	]
5			С	] x <sup>2</sup>
6			R/S	df

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#### 74 Stat 1–34A

## SPEARMAN'S RANK CORRELATION COEFFICIENT



Spearman's rank correlation coefficient is defined by

$$r_{s} = 1 - \frac{6 \sum_{i=1}^{n} D_{i}^{2}}{n (n^{2} - 1)}$$

where n = number of paired observations  $(x_i, y_i)$ 

$$D_i = \operatorname{rank}(x_i) - \operatorname{rank}(y_i) = R_i - S_i$$

If the X and Y random variables from which these n pairs of observations are derived are independent, then  $r_s$  has zero mean and a variance

$$\frac{1}{n-1}$$

A test for the null hypothesis

 $H_0$ : X, Y are independent

is using

$$z = r_s \sqrt{n-1}$$

which is approximately a standardized normal variable (for large n, say  $n \ge 10$ ).

If the null hypothesis of independence is not rejected, we can infer that the population correlation coefficient  $\rho(x, y) = 0$ , but dependence between the variables does not necessarily imply that  $\rho(x, y) \neq 0$ .

Note:  $-1 \leq r_s \leq 1$ 

 $r_s = 1$  indicates complete agreement in order of the ranks and  $r_s = -1$  indicates complete agreement in the opposite order of the ranks.

Reference: Nonparametric Statistical Inference, J. D. Gibbons, McGraw Hill, 1971

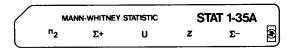
## Example:

	Xi	Уi	R <sub>i</sub>	Si
Student	Math Grade	Stat Grade	Rank of x <sub>i</sub>	Rank of y <sub>i</sub>
1	82	81	6	7
2	67	75	14	11
3	91	85	3	4
4	98	90	1	2
5	74	80	11	8
6	52	60	15	15
7	86	94	4	1
8	95	78	2	9
9	79	83	9	6
10	78	76	10	10
11	84	84	5	5
12	80	69	8	13
13	69	72	13	12
14	81	88	7	3
15	73	61	12	14

 $r_s = 0.76$ z = 2.85

LINE	INSTRUCTIONS	DATA KEYS		DISPLAY
1	Enter program			]
2	Initialize			]
3	Perform 3–4 for i = 1, 2,, n	Ri		]
4		Si	В	i
	(Correct erroneous data $R_k, S_k$ )	R <sub>k</sub>		]
		S <sub>k</sub>	E	
5			<b>C</b>	rs
6			D	z

#### MANN-WHITNEY STATISTIC



This program computes the Mann-Whitney test statistic on two independent samples of equal or unequal sizes. This test is designed for testing the null hypothesis of no difference between two populations.

Mann-Whitney test statistic is defined as

$$U = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - \sum_{i=1}^{n_1} R_i$$

where  $n_1$  and  $n_2$  are the sizes of the two samples. Arrange all values from both samples jointly (as if they were one sample) in an increasing order of magnitude, let  $R_i$  (i = 1, 2, ...,  $n_1$ ) be the ranks assigned to the values of the first sample (it is immaterial which sample is referred to as the "first").

When  $n_1$  and  $n_2$  are small, the Mann-Whitney test bases on the exact distribution of U and specially constructed tables. When  $n_1$  and  $n_2$  are both large (say, greater than 8) then

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

is approximately a random variable having the standard normal distribution.

Reference: Mathematical Statistics, J.E. Freund, Prentice Hall, 1962

#### Table for small samples:

Handbook of Statistical Tables, D.B. Owen, Addison-Wesley, 1962

#### Example:

Sample 1													
Rank R <sub>i</sub>	7	1	4	12	2 14	5	1	0 3	13	3			
Sample 2	15.2	19.8	14.7	18.3	16.2	21.2	18.9	12.2	15.3	19.4			
Rank	8	18	6	15	11	19	16	_2	9	17			
n <sub>1</sub> =	$n_1 = 9,  n_2 = 10$												
U = 66.00													
z = 1.71													

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			]
2		n <sub>2</sub>	<b>A</b>	]
3	Perform 3 for i=1, 2,, n <sub>1</sub>	Ri	В	] i
	(Correct erroneous data R <sub>k</sub> )	R <sub>k</sub>	E	
4	Compute U		С	] U
5	Compute z		D	] z

#### KENDALL'S COEFFICIENT OF CONCORDANCE

$$\begin{array}{c|c} & \text{KENDALL'S COEFFICIENT} \\ & \text{OF CONCORDANCE} \\ & \Sigma^{+} & \Sigma\Sigma^{+} & W & \chi^{2}, df & \Sigma^{-} \end{array}$$

Suppose n individuals are ranked from 1 to n according to some specified characteristic by k observers, the coefficient of concordance W measures the agreement between observers (or concordance between rankings).

$$W = \frac{12 \sum_{i=1}^{n} \left( \sum_{j=1}^{k} R_{ij} \right)^{2}}{k^{2} n(n^{2} - 1)} - \frac{3(n+1)}{n-1}$$

Where  $R_{ij}$  is the rank assigned to the i<sup>th</sup> individual by the j<sup>th</sup> observer.

W varies from 0 (no community of preference) to 1 (perfect agreement). The null hypothesis that the observers have no community of preference may be tested using special tables, or if n > 7, by computing

$$\chi^2 = k (n-1) W$$

which has approximately the chi-square distribution with n-1 degrees of freedom (df).

#### Reference: Nonparametric Statistical Inference, J. D. Gibbons, McGraw-Hill, 1971

#### Table for small samples:

Rank Correlation Methods, M.G. Kendall, Hafner Publishing Co., 1962

### Example:

	Table for $R_{ij}$ (n = 10, k = 3)								
i j	1	2	3						
1	6	7	3						
2	1	4	2						
3	9	3	5						
4	2	6	1						
5	10	8	9						
6	3	2	6						
7	5	9	8						
8	4	1	4						
9	8	10	10						
10	7	5	7						

W = 0.69 $\chi^2 = 18.64$ df = 9.00

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY	
1	Enter program				
2	Initialize		RTN R/S		
3	Perform 3–5 for i=1, 2,, n				
4	Perform 4 for j≃1, 2,, k	R <sub>ij</sub>		j	
	(Correct erroneous data R <sub>im</sub> )	R <sub>im</sub>	E		
5			В	i	
6	Compute W		С	w	
7	Compute $\chi^2$ and df		D	x <sup>2</sup>	
8			R/S	df	
	(For a new case, go to 2)				

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#### **BISERIAL CORRELATION COEFFICIENT**

BISERIAL CORRELATION COEFFICIENT STAT 1-37A  
INIT 
$$x_i=1$$
  $x_i=0$   $r_b$ 

The biserial correlation coefficient  $r_b$  is used where one variable Y is quantitatively measured while the other continuous variable X is artificially dichotomized (that is, artificially defined by two groups). It measures the degree of linear association between X and Y.

$$r_{b} = \frac{n (\Sigma' y_{i}) - n_{1} \Sigma y_{i}}{na \sqrt{n \Sigma y_{i}^{2} - (\Sigma y_{i})^{2}}}$$

Suppose X takes the value 0 or 1.

Define  $n_1 =$  number of x's such that x = 1

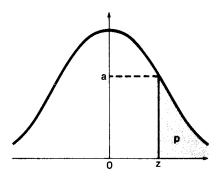
n = total number of data points

 $\Sigma' y_i$  = sum of the y's for which x = 1

 $\Sigma y_i = \text{sum of all y's}$ 

a = ordinate of the standard normal curve at point z cutting off a tail of that distribution with area

equal to 
$$p = \frac{n_1}{n}$$



Notes: 1.  $p = \frac{n_1}{n}$  must be less than or equal to 0.5, if not, interchange the roles of 0 and 1 for the X variable.

> 2. z and a can be found by using Stat 1-10A, Normal Distribution, and Stat 1-11A, Inverse Normal Integral.

- 3. Among the necessary assumptions for a meaningful interpretation of  $r_b$  are:
  - (a) Y is normally distributed
  - (b) the true distribution of X should be of normal form.

Reference: Statistics in Research, B. Ostle, Iowa State University Press, 1963

Example:

x <sub>i</sub>	0	1	1	0	1	0	0	0	1
y <sub>i</sub>	3.1	2.8	5.6	0.3	2.5	2.4	4.8	2.9	7.7
	I								
nı	= 4								
n	= 9								
Z	= 0.14								
а	= 0.40								
r <sub>b</sub>	= 0.60								

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program Stat 1-11A			
2			A	
3		ni		
4		n	÷B	z
5			STO 1	
6	Enter program Stat 1-10A1			
7			A	
8	Enter program Stat 1-10A2			
9			RCL 1	
10			A	a
11	Enter program Stat 1-37A			
12				]
13	Perform 14 or 15 for i=1,, n			]
14	lf x <sub>i</sub> = 1	Yi	В	]
15	lf x <sub>i</sub> = 0	Yi	С	]
16			D	r <sub>b</sub>

## PROGRAM LISTINGS

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## MEAN, STANDARD DEVIATION, STANDARD ERROR

CODE	KEYS	CODE	KEYS		CODE	KEYS
00	0	71	x		02	2
33 01	STO 1	51	_		32	f <sup>-1</sup>
33 02	STO 2	34 01	RCL 1		09	$\sqrt{\times}$
33 03	STO 3	81	÷		33	STO
84	R/S	31	f		51	—
23	LBL	09	$\sqrt{x}$		03	3
11	A	34 01	RCL 1		34 01	RCL1
33	STO	34 01	RCL 1		01	1
61	+	01	1		51	_
02	2	51	-		33 01	STO 1
32	f <sup>-1</sup>	81	÷		24	RTN
09	$\sqrt{x}$	31	f		35 01	g NOP
33	STO	09	$\sqrt{x}$		35 01	g NOP
61	+	71	x		35 01	g NOP
03	3	24	RTN	1	35 01	g NOP
34 01	RCL 1	35 07	gx <b></b> ∠y		35 01	g NOP
01	1	84	R/S		35 01	g NOP
61	+	23	LBL		35 01	g NOP
33 01	STO 1	14	D	[	35 01	g NOP
24	RTN	13	С		35 01	g NOP
23	LBL	34 01	RCL 1		35 01	g NOP
12	В	31	f _		35 01	g NOP
34 02	RCL 2	09	$\sqrt{x}$		35 01	g NOP
34 01	RCL 1	81	÷		35 01	g NOP
81	÷	35 07	g x <b></b> ≩y		35 01	g NOP
24	RTN	35 00	g LST X		35 01	g NOP
23	LBL	81	÷		35 01	g NOP
13	С	35 07	g x <b></b> ≩y		35 01	g NOP
34 03	RCL 3	84	R/S		35 01	g NOP
34 02	RCL 2	35 07	g x <b></b> ₹y		35 01	g NOP
34 01	RCL 1	24	RTN			
81	÷	23	LBL			
32	f <sup>-1</sup>	15	E			
09	$\sqrt{x}$	33	STO			
34 01	RCL 1	51	—			
L	I			J		

R <sub>1</sub>	n	R <sub>4</sub>	R <sub>7</sub>
R <sub>2</sub>	Σxi	R <sub>5</sub>	R <sub>8</sub>
R <sub>3</sub>	Σx <sub>i</sub> ²	R <sub>6</sub>	R <sub>9</sub>

#### MEAN, STANDARD DEVIATION, STANDARD ERROR (GROUPED DATA)

CODE	KEYS	CODE	KEYS		CODE	KEYS
00	0	34 02	RCL 2		35 07	g x <b></b> ₹y
33 01	STO 1	34 01	RCL 1		24	RTN
33 02	STO 2	81	÷		23	LBL
33 03	STO 3	32	f <sup>-1</sup>		15	E
33 04	STO 4	09	$\sqrt{x}$		42	CHS
84	R/S	34 01	RCL 1		11	А
23	LBL	71	x		34 04	RCL4
11	А	51	—		02	2
33	STO	34 01	RCL 1		51	- 1
61	+	81	÷		33 04	STO 4
01	1	31	f	[	24	RTN
35 07	gx <b></b> ∠y	09	$\sqrt{x}$		35 01	g NOP
71	x	34 01	RCL 1		35 01	g NOP
33	STO	34 01	RCL 1		35 01	g NOP
61	+	01	1		35 01	g NOP
02	2	51	_		35 01	g NOP
35 00	g LST X	81	÷		35 01	g NOP
71	x	31	f		35 01	g NOP
33	STO	09	$\sqrt{x}$		35 01	g NOP
61	+	71	x		35 01	g NOP
03	3	24	RTN		35 01	g NOP
01	1	35 07	g x <b></b> ,y		35 01	g NOP
34 04	RCL 4	84	R/S		35 01	g NOP
61	+	23	LBL		35 01	g NOP
33 04	STO 4	14	D		35 01	g NOP
24	RTN	13	С		35 01	g NOP
23	LBL	34 01	RCL 1		35 01	g NOP
12	В	31	f _		35 01	g NOP
34 02	RCL 2	09	$\sqrt{x}$		35 01	g NOP
34 01	RCL 1	81	÷		35 01	g NOP
81	÷	35 07	g x <b></b> ≩y			
24	RTN	35 00	g LST X			
23	LBL	81	÷			
13	С	35 07	g x <b></b> ≩y			
34 03	RCL 3	84	R/S			

R <sub>1</sub>	$\Sigma f_i$	<b>R</b> 4 n	R <sub>7</sub>
R <sub>2</sub>	Σf <sub>i</sub> x <sub>i</sub>	R <sub>5</sub>	R <sub>8</sub>
R <sub>3</sub>	$\Sigma f_i x_i^2$	R <sub>6</sub>	R <sub>9</sub>

# PERMUTATION AND COMBINATION

CODE	KEYS	]	CODE	KEYS	]	CODE	KEYS
23	LBL	ĺ	23	LBL	7	35 07	g x <b></b> ₹y
11	Α		03	3		61	+
35 24	g x>y		41	1		35 00	g LST X
22	GTO	ĺ	01	1		81	÷
02	2		24	RTN		34 06	RCL 6
41	1		23	LBL		71	x
00	0		12	В		33 06	STO 6
35 23	g x=y		35 24	g x>y		22	GTO
22	GTO		22	GTO		00	0
03	3	1	02	2		23	LBL
44	CLX		51		1	04	4
01	1		35 00	g LST X		35 08	gR↓
35 23	g x=y		35 22	g x≤γ		35 08	gR↓
22	GTO		33 06	STO 6		24	RTN
04	4		35 07	g x <b></b> ≩y		35 01	g NOP
51	-		33 07	STO 7		35 01	g NOP
33 08	STO 8		01	1		35 01	g NOP
35 08	gR↓		33 08	STO 8		35 01	g NOP
33 07	STO 7		61	+		35 01	g NOP
23	LBL		33 06	STO 6		35 01	g NOP
01	1		44	CLX		35 01	g NOP
34 07	RCL 7		35 23	g x=y		35 01	g NOP
01	1		01	1		35 01	g NOP
51	-	1	24	RTN		35 01	g NOP
33 07	STO 7		23	LBL		35 01	g NOP
71	x		00	0		35 01	g NOP
35	g		35 08	gR↓		35 01	g NOP
83	DSZ		01	1		35 01	g NOP
22	GTO		34 08	RCL 8		35 01	g NOP
01	1	1	61	+		35 01	g NOP
24	RTN		33 08	STO 8	-	•	
23	LBL		35 24	g x>y			
02	2		34 06	RCL 6			
00	0		24	RTN			
81	÷		34 07	RCL 7			

R <sub>1</sub>	R <sub>4</sub>		R <sub>7</sub>	Used
R <sub>2</sub>	R <sub>5</sub>		R <sub>8</sub>	Used
R <sub>3</sub>	R <sub>6</sub>	Used	R <sub>9</sub>	Used

## ARITHMETIC, GEOMETRIC, HARMONIC AND GENERALIZED MEANS

CODE	KEYS		CODE	KEYS		CODE	KEYS
01	1		33 05	STO 5		35 01	g NOP
33 02	STO 2		24	RTN		35 01	g NOP
44	CLX		23	LBL		35 01	g NOP
33 01	STO 1		12	В		35 01	g NOP
33 03	STO 3		34 01	RCL 1		35 01	g NOP
33 04	STO 4		34 05	RCL 5		35 01	g NOP
33 05	STO 5		81	÷		35 01	g NOP
84	R/S		24	RTN	1	35 01	g NOP
33	STO		23	LBL		35 01	g NOP
09	9		13	С		35 01	g NOP
84	R/S		34 02	RCL 2		35 01	g NOP
23	LBL		34 05	RCL 5		35 01	g NOP
11	А		35	g		35 01	g NOP
33	STO		04	g <sup>1</sup> /x	1	35 01	g NOP
61	+		35	l y		35 01	g NOP
01	1		05	y <sup>x</sup>		35 01	g NOP
33	STO		24	RTN		35 01	g NOP
71	×		23	LBL		35 01	g NOP
02	2		14	D		35 01	g NOP
35	g		34 05	RCL 5		35 01	g NOP
04	ī/x		34 03	RCL 3		35 01	g NOP
33	STO		81	÷		35 01	g NOP
61	+	İ	24	RTN		35 01	g NOP
03		1	23	LBL		35 01	g NOP
35 00	g LST X		15	E		35 01	g NOP
34	RCL		34 04	RCL 4		35 01	g NOP
09	9		34 05	RCL 5		35 01	g NOP
35	g		81	÷		35 01	g NOP
05			34	RCL		35 01	g NOP
33	STO		09	i		35 01	g NOP
61		1	35	g 1/			
04			04				
01		ĺ	35				
34 05			05	Υ^ • • •			
61	+		24	RTN			

R <sub>1</sub>	Σа	R <sub>4</sub>	Σa <sup>t</sup>	R <sub>7</sub>		
R <sub>2</sub>	Па	R <sub>5</sub>	n	R <sub>8</sub>		
R <sub>3</sub>	$\Sigma^1/_a$	R <sub>6</sub>		R <sub>9</sub>	t	

### SUMS FOR TWO VARIABLES

CODE	KEYS	CODE	KEYS	]	CODE	KEYS
23	LBL	51			34 04	RCL 4
11	А	04	4		84	R/S
33 07	STO 7	32	f <sup>-1</sup>		34 05	RCL 5
33	STO	09	$\sqrt{x}$		84	R/S
61	+	33	STO		34 06	RCL 6
04	4	51	_		84	R/S
32	f <sup>-1</sup>	05	5		35 01	g NOP
09	$\sqrt{x}$	35 07	gx <b></b> ≩y		35 01	g NOP
33	STO	33	STO		35 01	g NOP
61	+	51	—		35 01	g NOP
05	5	02	2		35 01	g NOP
35 07	g x <b></b> ≩y	32	f <sup>-1</sup>		35 01	g NOP
33	STO	09	$\sqrt{\mathbf{x}}$		35 01	g NOP
61	+	33	STO		35 01	g NOP
02	2	51			35 01	g NOP
32	f <sup>-1</sup>	03	3		35 01	g NOP
09	$\sqrt{x}$	35 00	g LST X		35 01	g NOP
33	STO	34 07	RCL 7		35 01	g NOP
61	+	71	x		35 01	g NOP
03	3	33	STO		35 01	g NOP
35 00	g LST X	51	-		35 01	g NOP
34 07	RCL 7	06	6		35 01	g NOP
71	x	34 01	RCL 1		35 01	g NOP
33	STO	01	1		35 01	g NOP
61	+	51	-		35 01	g NOP
06	6	33 01	STO 1		35 01	g NOP
34 01	RCL 1	24	RTN		35 01	g NOP
01	1	23	LBL		35 01	g NOP
61	+	13	С		35 01	g NOP
33 01	STO 1	34 01	RCL 1		35 01	g NOP
24	RTN	84	R/S			
23	LBL	34 02	RCL 2			
12	B	84	R/S			
33 07	STO 7	34 03	RCL 3			
33	STO	84	R/S			

R <sub>1</sub>	n	R <sub>4</sub>	Σy <sub>i</sub>	R <sub>7</sub>	Used
R <sub>2</sub>	Σx <sub>i</sub>	R <sub>5</sub>	Σy <sub>i</sub> <sup>2</sup>	R <sub>8</sub>	
R <sub>3</sub>	Σxi <sup>2</sup>	R <sub>6</sub>	Σx <sub>i</sub> y <sub>i</sub>	R <sub>9</sub>	

## **BASIC STATISTICS (TWO VARIABLES)**

CODE	KEYS		CODE	KEYS		CODE	KEYS
23	LBL		84	R/S		32	f <sup>-1</sup>
11	A		35 07	g x <b></b> ≩y		09	$\sqrt{x}$
34 02	RCL 2		24	RTN		34 01	RCL1
34 01	RCL 1		23	LBL		71	x
81	÷		13	С		51	-
84	R/S		34 06	RCL 6		34 01	RCL 1
34 04	RCL 4		34 02	RCL 2	1	01	1
34 01	RCL 1		34 04	RCL 4		51	-
81	÷		71	х		81	÷
24	RTN		34 01	RCL 1		31	f
23	LBL		81	÷		09	$\sqrt{x}$
12	В		51	-	ļ	24	RTN
34 03	RCL 3		34 01	RCL 1		35 01	g NOP
34 02	RCL 2		01	1		35 01	g NOP
15	E		51	—		35 01	g NOP
33 07	STO 7		81	÷		35 01	g NOP
84	R/S		24	RTN		35 01	g NOP
34 05	RCL 5		34	RCL		35 01	g NOP
34 04	RCL 4		09	9		35 01	g NOP
15	E		32	f <sup>-1</sup>		35 01	g NOP
33 08	STO 8		09	√x		35 01	g NOP
84	R/S		71	x		35 01	g NOP
34 01	RCL 1		84	R/S		35 01	g NOP
01	1		23	LBL		35 01	g NOP
51	-		14	D		35 01	g NOP
34 01	RCL 1		13	C		35 01	g NOP
81	÷		34 07	RCL 7		35 01	g NOP
31	f_		34 08	RCL 8		35 01	g NOP
09	$\sqrt{x}$	1	71	x		35 01	g NOP
33	STO		81	÷		35 01	g NOP
09	9		24	RTN			
71	x	1	23	LBL	1		
34 07	RCL 7	1	15	E			
35 00	g LST X		34 01	RCL 1	1		
71	x		81	÷			
L		-	L	<u> </u>	_		

R <sub>1</sub>	n	R <sub>4</sub>	Σγι	R <sub>7</sub>	\$ <sub>X</sub>
R <sub>2</sub>	Σxi	R <sub>5</sub>	$\Sigma \gamma_i^2$	R <sub>8</sub>	sy
R <sub>3</sub>	$\Sigma x_i^2$	R <sub>6</sub>	Σx <sub>i</sub> y <sub>i</sub>	R <sub>9</sub>	[(n-1)/n] ½

### MOMENTS, SKEWNESS AND KURTOSIS (FOR GROUPED OR UNGROUPED DATA) (CARD 1)

CODE	KEYS		CODE	KEYS	]	CODE	KEYS
33	STO		33	STO	1	33	STO
61	+		51	_		61	+
02	2		04	4	İ .	05	5
32	f <sup>-1</sup>	1	35 00	g LST X		24	RTN
09	$\sqrt{x}$		71	x		23	LBL
33	STO		33	STO		14	D
61	+		51	-		33	STO
03	3		05	5		51	—
35 00	g LST X		34 01	RCL 1		01	1
71	x		01	1	1	35 07	gx컱y
33	STO		51	—	[	71	×
61	+		33 01	STO 1		33	STO
04	4		24	RTN		51	-
35 00	g LST X		23	LBL		02	2
71	x		13	С		35 00	g LST X
33	STO		33	STO		71	x
61	+		61	+		33	STO
05	5		01	1		51	-
01	1		35 07	g x컱y		03	3
34 01	RCL 1		71	X		35 00	g LST X
61	+		33	STO		71	x
33 01	STO 1		61	+		33	STO
84	R/S		02	2		51	-
23	LBL		35 00	g LST X		04	4
12	B		71	x		35 00	g LST X
33	<b>STO</b>		33	STO		71	x
51	-		61	+		33	STO
02	2		03	3		51	-
32	f <sup>-1</sup>	1	35 00	g LST X		05	5
09	$\sqrt{x}$		71	x	l	24	RTN
33	STO		33	STO			
51	-		61	+			
03	3		04	4			
35 00	g LST X		35 00	g LST X			
71	x		71	x			

R <sub>1</sub>	n or Σf <sub>j</sub>	R <sub>4</sub>	$\Sigma x_i^3$ or $\Sigma f_j y_j^3$	R <sub>7</sub>
R <sub>2</sub>	$\Sigma x_i$ or $\Sigma f_j y_j$	$R_5$	$\Sigma x_i^4$ or $\Sigma f_j y_j^4$	R <sub>8</sub>
R <sub>3</sub>	$\Sigma x_i^2$ or $\Sigma f_j y_j^2$	<sup>2</sup> R <sub>6</sub>		R <sub>9</sub>

#### MOMENTS, SKEWNESS AND KURTOSIS (FOR GROUPED OR UNGROUPED DATA) (CARD 2)

CODE	KEYS	CODE	KEYS		CODE	KEYS
23	LBL	61	+		83	•
11	A	33	STO		05	5
34 02	RCL 2	09	9		35	g
34 01	RCL 1	24	RTN		05	y×
81	÷	23	LBL		81	÷
33 06	STO 6	14	D		84	R/S
24	RTN	34 05	RCL 5		34 06	RCL 6
23	LBL	34 06	RCL 6		34 07	RCL 7
. 12	В	34 04	RCL 4		32	f <sup>-1</sup>
34 03	RCL 3	71	x		09	√x
34 01	RCL 1	04	4		81	÷
81	÷	71	x		24	RTN
34 06		51	·		35 01	g NOP
32		34 08	RCL 8		35 01	g NOP
09		34 03	RCL 3		35 01	g NOP
33 08		71	x		35 01	g NOP
51		06	6		35 01	g NOP
33 07		71	x		35 01	g NOP
24		61	+		35 01	g NOP
23		34 01	RCL 1		35 01	g NOP
13		81	÷		35 01	g NOP
34 04		34 08	RCL 8		35 01	g NOP
34 03		32	f <sup>-1</sup>		35 01	g NOP
34 06	RCL 6	09	$\sqrt{x}$		35 01	g NOP
71	x	03	3		35 01	g NOP
03		71	x		35 01	g NOP
71	x	51	-	ĺ	35 01	g NOP
51		33 06	STO 6	ļ	35 01	g NOP
34 01	RCL 1	24	RTN		35 01	g NOP
81		23	LBL.		35 01	g NOP
34 06		15	E			
34 08		34	RCL			
71		09	9			
02		34 07	RCL 7 1			
71	x	01	T			

R <sub>1</sub>	n or Σf <sub>j</sub>	R <sub>4</sub>	$\Sigma x_i^3$ or $\Sigma f_j y_j^3$	R <sub>7</sub>	m <sub>2</sub>
R <sub>2</sub>	$\Sigma x_i$ or $\Sigma f_j y_j$	R <sub>5</sub>	$\Sigma x_i^4$ or $\Sigma f_j y_j^4$	R <sub>8</sub>	$\overline{x}^2$
R <sub>3</sub>	$\Sigma x_i^2$ or $\Sigma f_j y_j^2$	R <sub>6</sub>	x, m4	R <sub>9</sub>	m <sub>3</sub>

## **RANDOM NUMBER GENERATOR**

CODE	KEYS	]	CODE	KEYS	7	CODE	KEYS
23	LBL	1	31	f	1	34 01	RCL 1
11	A		07	LN		33 06	STO 6
00	0		02	2		34 02	RCL 2
33 01	STO 1		7,1	x		33 01	STO 1
24	RTN		42	CHS		12	В
23	LBL		31	f		33 02	STO 2
12	В		09	$\sqrt{x}$		34 06	RCL6
35	g		33 05	STO 5		33 01	STO 1
02	π		34 01	RCL 1		12	В
34 01	RCL 1		35	g		34 05	RCL 5
61	+		02	π		84	R/S
08	8		71	x		35 01	g NOP
35	g		02	2		35 01	g NOP
05	y×,		71	x		35 01	g NOP
32	f <sup>-1</sup>		33 06	STO 6		35 01	g NOP
83	INT		31	f		35 01	g NOP
33 01	STO 1		05	COS		35 01	g NOP
24	RTN		71	x		35 01	g NOP
23	LBL		34 04	RCL 4		35 01	g NOP
13	С		71	х		35 01	g NOP
33 04	STO 4		34 03	RCL 3		35 01	g NOP
35 07	g x <b></b> ∠y		61	+		35 01	g NOP
33 03	STO 3		84	R/S		35 01	g NOP
24	RTN		23	LBL		35 01	g NOP
23	LBL		15	E		35 01	g NOP
14	D		34 06	RCL 6		35 01	g NOP
33 01	STO 1		31	f		35 01	g NOP
35 07	g x <b></b> ₹y		04	SIN		35 01	g NOP
33 02	STO 2		34 05	RCL 5		35 01	g NOP
24	RTN		71	x		35 01	g NOP
23	LBL		34 04	RCL 4			
15	E		71	x			
35	g		34 03	RCL 3			
42	RAD		61	+			
34 02	RCL 2		33 05	STO 5			

R <sub>1</sub>	Used	R <sub>4</sub>	σ	R <sub>7</sub>	
R <sub>2</sub>	Used	R <sub>5</sub>	Used	R <sub>8</sub>	
R <sub>3</sub>	m	R <sub>6</sub>	Used	R <sub>9</sub>	Used

ANALYSIS OF VARIANCE (ONE WAY)

CODE	KEYS	ļ	CODE	KEYS		CODE	KEYS
23	LBL		33	STO		34 05	RCL 5
11	A		61	+		34 04	RCL 4
33	STO		05	5		51	-
61	+		00	0		33	STO
01	1		33 01	STO 1		09	9
32	f <sup>-1</sup>		33 02	STO 2		81	÷
09	$\sqrt{x}$		34 08	RCL 8		81	÷
33	ŠТО		84	R/S		84	R/S
61	+		23	LBL		34 08	RCL 8
06	6		13	С		84	R/S
01	1		34 06	RCL 6		34	RCL
34 02	RCL 2		34 07	RCL 7 -		09	9
61	+		32	f <sup>-1</sup>		84	R/S
33 02	STO 2		09	$\sqrt{x}$		23	LBL
84	R/S	ļ	34 05	RCL 5	1	14	D
23	LBL		81	÷		33	STO
12	В	÷	51	-	1	51	-
01	1		33 01	STO 1		01	
33	STO	ļ	34 03	RCL 3		32	f <sup>-1</sup>
61	+		34 07	RCL 7		09	$\sqrt{x}$
04	4		32	f <sup>-1</sup>		33	STO
34 01	RCL 1		09	$\sqrt{x}$		51	-
32	f <sup>-1</sup>		34 05	RCL 5		06	6
09	$\sqrt{x}$		81	÷	1	34 02	RCL 2
34 02	RCL 2		51	-		01	1
81	÷		33 02	STO 2		51	-
33	STO		51	-		33 02	STO 2
61	+		33 03	STO 3		84	R/S
03	3		35 00	g LST X		35 01	g NOP
34 01	RCL 1		34 04	RCL 4		35 01	g NOP
33 08			01	1			
33	STO		51	-			
61	+		33 08	STO 8			
07			81	÷			
34 02	RCL 2		35 07	g x <b></b> ₹y			

R <sub>1</sub>	Used	R <sub>4</sub>	Used	R <sub>7</sub>	$\Sigma\Sigma x_{ij}$
R <sub>2</sub>	Used	R <sub>5</sub>	Σni	R <sub>8</sub>	df <sub>1</sub>
R <sub>3</sub>	Used	R <sub>6</sub>	$\Sigma\Sigma x_{ij}^{2}$	R <sub>9</sub>	df <sub>2</sub>

## **NORMAL DISTRIBUTION (CARD 1)**

CODE	KEYS		CODE	KEYS	CODE	KEYS
23	LBL	1	33 05	STO 5	24	RTN
11	Α		01	1	35 01	g NOP
83	•		83	•	35 01	g NOP
02	2		07	7	35 01	g NOP
03	3		08	8	35 01	g NOP
01	1		01	1	35 01	g NOP
06	6		04	4	35 01	g NOP
04	4		07	7	35 01	g NOP
01	1		07	7	35 01	g NOP
09	9		09	9	35 01	g NOP
33 03	STO 3		03	3	35 01	g NOP
01	1		07	7	35 01	g NOP
83	•		33 06	STO 6	35 01	g NOP
03	3		83	•	35 01	g NOP
03	3		03	3	35 01	g NOP
00	0		05	5	35 01	g NOP
02	2	•	• 06	6	35 01	g NOP
07	7		05	5	35 01	g NOP
04	4		06	6	35 01	g NOP
04	4		03	3	35 01	g NOP
02	2		07	7	35 01	g NOP
09	9		08	8	35 01	g NOP
33 04	STO 4		02	2	35 01	g NOP
01	1		42	CHS	35 01	g NOP
83	•		33 07	STO 7	35 01	g NOP
08	8		83	•	35 01	g NOP
02	2	- 1	03	3	35 01	g NOP
01	1		01	1	35 01	g NOP
02	2		09	9	35 01	g NOP
05	5	Ì	03	3	35 01	g NOP
05	5		08	8	I	-
09	9		01	1		
07	7		05	5		
08	8		03	3		
42	CHS		33 08	STO 8		

R <sub>1</sub>		R <sub>4</sub>	b <sub>5</sub>	R <sub>7</sub>	b <sub>2</sub>
R <sub>2</sub>		R <sub>5</sub>	b4	R <sub>8</sub>	b <sub>1</sub>
R <sub>3</sub>	r	R <sub>6</sub>	b <sub>3</sub>	R <sub>9</sub>	

# NORMAL DISTRIBUTION (CARD 2)

CODE	KEYS		CODE	KEYS		CODE	KEYS
23	LBL		41	1		35 01	g NOP
11	A		41	1		35 01	g NOP
33 01	STO 1		41	1		35 01	g NOP
41	↑		34 04	RCL 4		35 01	g NOP
71	x		71	x		35 01	g NOP
02	2		34 05	RCL 5		35 01	g NOP
81	÷		61	+		35 01	g NOP
42	CHS		71	x		35 01	g NOP
32	f <sup>-1</sup>		34 06	RCL 6		35 01	g NOP
07	ĹΝ		61	+		35 01	g NOP
35	g		71	x		35 01	g NOP
02	π		34 07	RCL 7		35 01	g NOP
02	2		61	+	]	35 01	g NOP
71	x		71	x		35 01	g NOP
31	f		34 08	RCL 8	1	35 01	g NOP
09	$\sqrt{x}$		61	+		35 01	g NOP
81	÷		71	x		35 01	g NOP
33 02	STO 2		34 02	RCL 2		35 01	g NOP
24	RTN	ľ	71	x		35 01	g NOP
23	LBL		24	RTN		35 01	g NOP
12	В		23	LBL		35 01	g NOP
34 01	RCL 1		01	1		35 01	g NOP
00	0		34 01	RCL 1		35 01	g NOP
35 24	g x>y		42	CHS		35 01	g NOP
22	GTO		33 01	STO 1		35 01	g NOP
01	1		13	С	1	35 01	g NOP
23	LBL		01	1		35 01	g NOP
13	С		35 07	g x <b></b> ∠y		35 01	g NOP
01	1		51	_		35 01	g NOP
34 01	RCL 1		24	RTN	1	35 01	g NOP
34 03	RCL 3	1	35 01	g NOP		L	1
71	x		35 01	g NOP			
61	+		35 01	g NOP			
35	g		35 01	g NOP			
04	<sup>ĭ</sup> /x		35 01	g NOP			

R <sub>1</sub>	x or -x	R <sub>4</sub>	b5	R <sub>7</sub>	b <sub>2</sub>
R <sub>2</sub>	f(x)	R <sub>5</sub>	b4	R <sub>8</sub>	b <sub>1</sub>
R <sub>3</sub>	r	R <sub>6</sub>	b3	R <sub>9</sub>	Used

# **INVERSE NORMAL INTEGRAL**

CODE	KEYS	]	CODE	KEYS	7	CODE	KEYS
02	2	]	01	1	1	07	LN
83	•		08	8		31	f
05	5		09	9		09	$\sqrt{x}$
01	1		02	2		33 07	STO 7
05	5		06	6		34 03	RCL 3
05	5		09	9		71	x
01	1		33 05	STO 5		34 02	RCL 2
07	7		83	•		61	+
33 01	STO 1		00	0	1	34 07	RCL7
83	•		00	0		71	x
08	8		01	1		34 01	RCL 1
00	0		03	3		61	+
02	2		00	0		34 07	RCL 7
08	8		08	8		34 06	RCL 6
05	5		33 06	STO 6		71	×
03	3	•	24	RTN		34 05	RCL 5
33 02	STO 2		23	LBL		61	+
83	•		12	В		34 07	RCL7
00	0		41	1		71	x
01	1		00	0		34 04	RCL4
00	0		35 24	g x>γ		61	+
03	3		00	0		34 07	RCL 7
02	2		81	÷		71	x
80	8		35 08	gR↓	1 1	01	1
33 03	STO 3		83	•		61	+
01	1		05	5		81	÷
83			35 07	g x <b></b> ₹y		34 07	RCL 7
04	4		35 24	g`x>y		35 07	gx컱y
03	3		00	0		51	-
02	2		81	÷	L	24	RTN
07	7		41	↑			
08	8		71	x			
08	8		35	g <sup>1</sup> /x			
33 04 83	STO 4		04	<sup>-</sup> /x f			
03			31	1			

R <sub>1</sub>	c <sub>0</sub>	R <sub>4</sub>	d <sub>1</sub>	R <sub>7</sub>	t
R <sub>2</sub>	C1	R <sub>5</sub>	d <sub>2</sub>	R <sub>8</sub>	
R <sub>3</sub>	C2	R <sub>6</sub>	d₃	R <sub>9</sub>	Used

## CHI-SQUARE DISTRIBUTION

01       1       35       g       34       01       RCL 1         33       03       STO 3       02 $\pi$ 33       STO 1       02 $\pi$ 35       07       g x≥y       31       f       33       STO 7       STO 3       STO 7	CODE	KEYS		CODE	KEYS		CODE	KEYS
33 03       STO 3       02       π       81       ÷         35 07       g x≥y       31       f       33       STO 3         02       2       09       √x       71       x         81       ÷       34<03	01	1		35	g		34 01	RCL 1
3507g x ≥ y31f33STO02209 $\sqrt{x}$ 71x81 $\div$ 3403RCL 30553301STO 171x02231f3303STO 33401RCL 183INT84R/S71x0223500g LST X23LBL3306STO 63521g x≠y12B01122GTO3302STO 23304STO 40113401RCL 123LBL01105y <sup>x</sup> 0223406RCL 603n!05y <sup>x</sup> 0223406RCL 603330STO 33402RCL 261+3306STO 623LBL81 $\div$ 0223306STO 681 $\div$ 03332f <sup>-1</sup> 3304STO 461+3304STO 43523g x=y71x3304STO 461+3304STO 43523g x=y71x3304STO 461+22GTO3333033303330333033303333303 <td></td> <td>STO 3</td> <td></td> <td></td> <td>-</td> <td></td> <td>81</td> <td>÷</td>		STO 3			-		81	÷
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$				31	f		33	STO
81 $\div$ 34<03RCL 305533<01				09	$\sqrt{x}$			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	81			34 03	RCL 3			
83INT84 $R/S$ 71x3500 $g LST X$ 23 $LBL$ 3306 $STO 6$ 3521 $g x \neq y$ 12B01122 $GTO$ 3302 $STO 2$ 3304 $STO 4$ 011011103351-51-3402RCL 235g35g3402RCL 23303STO 33402RCL 2613306STO 63306STO 63303STO 33402RCL 2613404RCL 481 $\div$ 81 $\div$ 01142CHS3404RCL 483 $\cdot$ 32 $f^{-1}$ 71x05507LN3304STO 43523 $g x = y$ 71x61+22GTO0223401RCL 1223507 $g x \neq y$ 35g03305507LN3304STO 43507 $g x \neq y$ 35g03301105 $y^x$ 3405RCL 551-81 $\div$ 71x33STO3403RCL 384R/S3501123LBL	33 01	STO 1		71	x			
3500g LST X23LBL3306STO 63521 $g \neq y$ 12B01122GTO3302STO 23304STO 40113401RCL 1033301101101103351-51-3402RCL 235g35g0223303STO 33402RCL 23303STO 33402RCL 23303STO 33402RCL 23306STO 631÷23LBL81÷8101142CHS3483•32f <sup>-1</sup> 7105507LN333593404RCL 43523 $g x=y$ 71x05507LN333507 $g x \neq y$ 35g3507 $g x \neq y$ 35g33STO3403RCL 371x81÷333305STO 522GTO84R/S01123LBL23LBL13C	31	f			_			RCL 1
35       21 $g x \neq y$ 12       B       01       1         22       GTO       33       02       STO 2       33       04       STO 4         01       1       01       1       RCL 1       23       LBL       03       3         01       1       01       1       -       34       01       RCL 1       03       3         01       1       01       1       -       34       02       RCL 2       34       06       RCL 6         03       n!       05       y×       02       2       34       06       RCL 6       02       2       61       +       02       2       61       +       02       2       61       +       02       2       33       06       STO 6       81       ÷       02       2       33       06       STO 6       81       ÷       33       04       RCL 4       71       x       33       04       STO 6       81       ÷       05       5       07       LN       33       04       STO 4       61       +       22       GTO       03       3       03       34       05	83	INT			R/S			
33       02       STO 2       33       04       STO 4         01       1       34       01       RCL 1       03       3         01       1       01       1       01       1       03       3         51       -       35       g       35       g       34       02       RCL 2         33       03       STO 3       34       02       RCL 2       61       +         33       04       STO 6       81       ÷       33       06       STO 6         33       03       STO 3       34       02       2       61       +         33       04       STO 6       81       ÷       33       04       RCL 6         03       3       02       2       33       06       STO 6       81       ÷         01       1       42       CHS       34       04       RCL 4       71       x         05       5       07       LN       33       04       STO 4       61       +         22       GTO       02       2       34       05       RCL 5       71       x         <	35 00	g LST X		23	LBL			
$22$ $310$ $34$ $01$ $RCL$ $23$ $LBL$ $01$ $1$ $01$ $1$ $01$ $1$ $03$ $3$ $51$ $ 51$ $ 34$ $02$ $RCL$ $2$ $35$ $g$ $35$ $g$ $34$ $02$ $RCL$ $2$ $33$ $03$ $STO$ $34$ $02$ $RCL$ $2$ $34$ $06$ $RCL$ $61$ $33$ $03$ $STO$ $34$ $02$ $2$ $33$ $06$ $STO$ $61$ $+$ $33$ $02$ $2$ $33$ $06$ $STO$ $61$ $+$ $01$ $1$ $42$ $CHS$ $34$ $04$ $RCL$ $4$ $83$ $\cdot$ $32$ $f^{-1}$ $33$ $04$ $RCL$ $4$ $35$ $23$ $g$ $g$ $71$ $x$ $61$ $+$ $22$ $GTO$ $02$ $2$ $34$ $05$ $RCL$ <td>35 21</td> <td>g x≠y</td> <td></td> <td>12</td> <td></td> <td></td> <td></td> <td></td>	35 21	g x≠y		12				
01101103351-35g35g3402RCL 235g05 $y^x$ 0223406RCL 603n!05 $y^x$ 02261+3303STO 33402RCL 261+84R/S0223306STO 623LBL81 $\div$ 3404RCL 483·32f <sup>-1</sup> 71x05507LN3304STO 43523g x=y71x61+22GTO0223401RCL 13507g x≥y35g03301105 $y^x$ 3405RCL 551-81 $\div$ 3405RCL 551-81 $\div$ 3305STO 522GTO84R/S3501g NOP0333305STO 53501g NOP0333305STO 53501g NOP0333305STO 53501g NOP033LBL13C	22	GTO		33 02	1			
51       -       51       -       34       02       RCL 2         35       g       05 $y^x$ 02       2       34       06       RCL 6         03       n!       05 $y^x$ 02       2       31       06       RCL 6         33       03       STO 3       34       02       RCL 2       61       +         84       R/S       02       2       33       06       STO 6         23       LBL       81       ÷       81       ÷       81       ÷         01       1       42       CHS       34       04       RCL 4         83       ·       32       f <sup>-1</sup> 34       04       RCL 4         83       ·       32       f <sup>-1</sup> 33       04       RCL 4         35       23       g x=y       71       x       61       +         22       GTO       02       2       35       21       g x≠y         05       5       07       LRL       33       34       05       RCL 5         51       -       81       ÷       34       05       RCL 5	01	1						
35g35g3406RCL 603n!05 $y^x$ 02261+3303STO 33402261+34R/S0223306STO 623LBL81 $\div$ 81 $\div$ 81 $\div$ 01142CHS3404RCL 483 $\cdot$ 32f <sup>-1</sup> 71x05507LN3304STO 43523g x=y71x61+22GTO0223401RCL 13507g x₹y35g03301105 $y^x$ 3405RCL 551-81 $\div$ 71x33STO3403RCL 384R/S71x81 $\div$ 3501g NOP0333305STO 53501g NOP0333305STO 5501g NOP0333305STO 551901123LBL13C	01	1		01	1			
3333405 $y^{x}$ 0223303STO 33402RCL 261+3303STO 30223306STO 623LBL81 $\div$ 81 $\div$ 81 $\div$ 01142CHS3404RCL 483 $\cdot$ 32f <sup>-1</sup> 71x05507LN3304STO 43523g x=y71x61+22GTO0223521g x≠y0223401RCL 122GTO3507g x≥y35g03301105y <sup>x</sup> 3405RCL 551-81 $\div$ 71x33STO3403RCL 384R/S71x81 $\div$ 3501g NOP0333305STO 53501g NOP0333305STO 53501g NOP0331305STO 53501g NOP0331123LBL13C-	51	_		51	-			
33       03       STO 3       34       02       RCL 2       61       +         33       03       STO 3       02       2       33       06       STO 6         23       LBL       81       ÷       81       ÷       81       ÷         01       1       42       CHS       34       04       RCL 4         83       •       32       f <sup>-1</sup> 71       x         05       5       07       LN       33       04       STO 4         35       23       g x=y       71       x       61       +         22       GTO       02       2       35       21       g x≠y         02       2       34       01       RCL 1       22       GTO         35       07       g x≥y       35       g       03       3       3         01       1       05       y <sup>×</sup> 34       05       RCL 3       84       R/S         33       STO       34       03       RCL 3       35       01       g NOP         03       3       33       05       STO 5       35       01       g NO	35	g		35				
84       R/S       02       2       33       06       STO 6         23       LBL       81 $\div$ 81 $\div$ 81 $\div$ 01       1       42       CHS       34       04       RCL 4         83       •       32       f <sup>-1</sup> 71       x       33       06       STO 6         05       5       07       LN       33       04       RCL 4       71       x         05       5       07       LN       33       04       STO 4         35       23       g x=y       71       x       61       +         22       GTO       02       2       35       9       03       3         02       2       34       01       RCL 1       22       GTO       03       3         35       07       g x≥y       35       g       03       3       33       05       RCL 5       71       x         31       -       81 $\div$ 71       x       84       R/S       35       01       g NOP         03       3       33       05       STO 5	03	n!		05			•	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	33 03	STO 3		34 02		1		1
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	84	R/S		02	2			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	23	LBL		81	÷	1		1
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	01	1					34 04	RCL 4
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	83	•			1			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	05	5		07	LN			1
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	35 23	g x=y		71				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	22							
01       1       05       y*       34       05       RCL 5         51       -       81       ÷       71       x         33       STO       34       03       RCL 3       84       R/S         33       STO       34       03       RCL 3       84       R/S         03       3       33       05       STO 5       35       01       g NOP         01       1       23       LBL       13       C       Image: constraint of the second sec	02	2		34 01	RCL 1			
51       -       81       ÷       71       ×         33       STO       34       03       RCL 3       84       R/S         71       x       81       ÷       35       01       g NOP         03       3       33       05       STO 5       35       01       g NOP         23       LBL       13       C       -       -       -       -	35 07	g x <b></b> ₹y		35	g			-
33     STO     34     03     RCL 3     84     R/S       71     x     81     ÷     35     01     g NOP       03     3     33     05     STO 5     32     GTO     84     R/S       01     1     23     LBL     13     C     F	01	1		05	y×			RCL 5
71     x     81     ÷     35     01     g NOP       03     3     33     05     STO 5     32     GTO     84     R/S       01     1     23     LBL     13     C	51	-						
03     3     33     05     STO 5       22     GTO     84     R/S       01     1     23     LBL       23     LBL     13     C	33	STO				1		
22         GTO         84         R/S           01         1         23         LBL           23         LBL         13         C							35 01	g NOP
01 1 23 LBL 23 LBL 13 C			1			1		
23 LBL 13 C						1		
			1					
1 02 2 1 1 34 02 RCL 2 1			1					
	02	2		34 02	RCL 2			

R <sub>1</sub>	v/2	R <sub>4</sub>	Used	R <sub>7</sub>	
R <sub>2</sub>	x	R <sub>5</sub>	Used	R <sub>8</sub>	
R <sub>3</sub>	1, Γ(ν/2)	R <sub>6</sub>	Used	R <sub>9</sub>	Used

## t **DISTRIBUTION**

CODE	1	]	CODE	KEYS	]	CODE	KEYS
23	LBL	7	02	2	1	02	2
11	A		35 23	g x≃y		34 02	RCL 2
33 01	STO 1		34 04	RCL 4		02	2
35	g		24	RTN		71	x
42	RAD		81	÷		35	g
31	f_		01	1		02	π
09	$\sqrt{x}$		51	-		81	÷
81	÷		33 08	STO 8		33 07	STO 7
32	f <sup>-1</sup>		01	1		34 01	RCL1
06	TAN	1	33 06	STO 6		01	1
33 02	STO 2		23	LBL		33 05	STO 5
34 01	RCL 1		01	1		33	STO
02	2		34 03	RCL 3		51	_
81	÷		71	x		01	1
31	f		34 05	RCL 5		35 23	g x=y
83	INT		01	1		34 07	RCL 7
35 00	g LST X	·	61	+		24	RTN
35 21	g x≠y		71	x		12	в
22	GTO		35 00	g LST X		34 02	RCL 2
02	2		01	1		31	f
00	0		61	+		05	cos
33 05	STO 5		33 05	STO 5		71	x
23	LBL		81	÷		02	2
12	В		33	STO		71	x
34 02	RCL 2		61	+		35	g
31	f		06	6		02	π
05	cos		35	g		81	÷
32	f <sup>-1</sup>		83	DSZ		34 07	RCL 7
09	$\sqrt{x}$		22	GTO		61	+
33 03	STO 3		01	1		24	RTN
34 02	RCL 2		34 06	RCL 6	L		
31	f		34 04	RCL 4			
04	SIN		、71	x			
33 04	STO 4		24	RTN			
34 01	RCL 1		23	LBL			
		L					

R <sub>1</sub>	ν or ν – 1	R <sub>4</sub>	sin θ	R <sub>7</sub>	2θ/π
R <sub>2</sub>	θ	R <sub>5</sub>	Used	R <sub>8</sub>	Used
R <sub>3</sub>	$\cos^2 \theta$	R <sub>6</sub>	Used	R <sub>9</sub>	Used

## F DISTRIBUTION

CODE	KEYS		CODE	KEYS	]	CODE	KEYS
33 01	STO 1		35 23	g x=y	]	33	STO
24	RTN		34 04	RCL 4		61	+
23	LBL		24	RTN		05	5
12	B		01	1		35	g
33 02	STO 2		33 05	STO 5		83	DSZ
24	RTN		34 03	RCL 3	1	22	GTO
23	LBL		51	-		03	3
13	Ĉ		33 03	STO 3		23	LBL
41	1		34 02	RCL 2		02	2
34 01	RCL 1		02	2		34 05	RCL 5
71	x		81	÷		34 04	RCL 4
34 02	RCL 2		71	x		71	×
61	+		33	STO		24	RTN
34 02	RCL 2		61	+		23	LBL
35 07	g x <b></b> ₹y		05	5		15	E
81	÷		35	g		34 01	RCL 1
33 03	STO 3		83	DSZ		34 02	RCL 2
24	RTN		22	GTO		33 01	STO 1
23	LBL		03	3		35 07	g x <b></b> ₹y
14	D		22	GTO		33 02	STO 2
34 03	RCL 3		02	2		01	1
34 02	RCL 2		23	LBL		34 03	RCL 3
02	2		03	3		51	-
33 07	STO 7		34 02	RCL 2		33 03	STO 3
81	÷		02	2		14	D
35	g		61	+		01	1
05	y×		33 02	STO 2		35 07	g x <b></b> ⊄y
33 04	STO 4		34 07	RCL 7		51	-
34 01	RCL 1		02	2		84	R/S
02	2		61	+		35 01	g NOP
51	-		33 07	STO 7			
02	2		81	÷			
81	÷		34 03	RCL 3			
33 08			71	x			
00	0		71	×			

R <sub>1</sub>	$v_1$ or $v_2$	<b>R</b> <sub>4</sub> $t^{\nu_2/2}$ or $t^{\nu_1/2}$	R <sub>7</sub>	Used	
R <sub>2</sub>	$v_2$ or $v_1$	R <sub>5</sub> Used	R <sub>8</sub>	Used	
R <sub>3</sub>	t, 1 – t	R <sub>6</sub>	R <sub>9</sub>	Used	

# BIVARIATE NORMAL DISTRIBUTION

CODE		]	CODE	KEYS	7	CODE	KEYS
23	LBL		34 02	RCL 2	1	35 01	g NOP
11	A		34 04	RCL 4		35 01	g NOP
33 01	STO 1		71	x		35 01	g NOP
35 07	g x <b></b> ≩y		02	2		35 01	g NOP
33 06	STO 6		71	×		35 01	g NOP
24	RTN		34 05	RCL 5		35 01	g NOP
23	LBL		71	x		35 01	g NOP
12	В		51	-		35 01	g NOP
33 03	STO 3		01	1		35 01	g NOP
35 07	g x <b></b> ≵γ		34 05	RCL 5		35 01	g NOP
33 07	STO 7		32	f <sup>-1</sup>		35 01	g NOP
24	RTN		09	$\sqrt{x}$		35 01	g NOP
23	LBL		51	-		35 01	g NOP
13	C		33 08	STO 8		35 01	g NOP
33 05	STO 5		02	2		35 01	g NOP
24	RTN		71	×		35 01	g NOP
23	LBL		81	÷		35 01	g NOP
14	D		42	CHS		35 01	g NOP
35 07	g x <b></b> ≩y		32	f <sup>-1</sup>		35 01	g NOP
34 06 51	RCL 6		07	LN		35 01	g NOP
34 01			34 08	RCL 8		35 01	g NOP
81	RCL 1 ÷		31	f		35 01	g NOP
33 02	STO 2		09	√x DOI 1		35 01	g NOP
32	f <sup>-1</sup>		34 01	RCL 1		35 01	g NOP
09	$\sqrt{x}$		71 34 03	X		35 01	g NOP
35 07	v^ g x <b></b> ≩y		34 03 71	RCL 3		35 01	g NOP
34 07	RCL 7		02	x 2		35 01	g NOP
51	-		71	x		35 01	g NOP
34 03	RCL 3		35			35 01 35 01	g NOP
81	÷		02	9 π	L	30 01	g NOP
33 04	STO 4		71	x			
32	f <sup>-1</sup>		81	÷			
09	$\sqrt{x}$		24	RTN			
61	+		35 01	g NOP			
		L					

R <sub>1</sub>	$\sigma_1$	R <sub>4</sub>	$(y - \mu_2)$	)/σ <sub>2</sub> <b>R</b> 7	μ2
R <sub>2</sub>	$(x - \mu_1)$	$\sigma_1   \mathbf{R_5}$	ρ	R <sub>8</sub>	$1 - \rho^2$
R <sub>3</sub>	σ2	R <sub>6</sub>	$\mu_1$	R <sub>9</sub>	

# LOGARITHMIC NORMAL DISTRIBUTION

CODE	KEYS	[	CODE	KEYS		CODE	KEYS
23	LBL	ľ	71	x		35 01	g NOP
11	A		24	RTN		35 01	g NOP
33 02	STO 2		23	LBL		35 01	g NOP
35 07	g x <b></b> ∠y		15	E		35 01	g NOP
33 01	STO 1		33 03	STO 3		35 01	g NOP
32	f <sup>-1</sup>		31	f		35 01	g NOP
07	LN		07	LN		35 01	g NOP
24	RTN		34 01	RCL 1	ļ	35 01	g NOP
23	LBL		51		ļ	35 01	g NOP
12	В		32	f <sup>-1</sup>		35 01	g NOP
34 01	RCL 1		09	$\sqrt{x}$		35 01	g NOP
34 02	RCL 2	1	34 02	RCL 2	1	35 01	g NOP
51	-		81	÷		35 01	g NOP
32	f <sup>-1</sup>		02	2		35 01	g NOP
07	LN		81	÷	1	35 01	g NOP
24	RTN		42	CHS		35 01	g NOP
23	LBL		32	f <sup>-1</sup>	1	35 01	g NOP
13	С		07	LN		35 01	g NOP
34 01	RCL 1		35	g		35 01	g NOP
34 02	RCL 2		02	π		35 01	
02	2		02	2		35 01	g NOP
81	÷		71	X		35 01	g NOP
61	+.		34 02	RCL 2		35 01	g NOP g NOP
32			71	x	Ì	35 01	g NOP
07			31	f_		35 01	g NOP
24			09	$\sqrt{x}$		35 01	g NOP
23	1		81	÷		35 01	-
14			34 03	RCL 3			
32			81	÷		35 01	
09			24			35 01	y NOI
34 02			35 01	g NOP			
32		1	35 01	g NOP	1		
07			35 01	g NOP g NOP	1		
01			35 01				
51	I   -		35 01	y NOP			

R <sub>1</sub>	m	R <sub>4</sub>	R <sub>7</sub>
R <sub>2</sub>	$\sigma^2$	R <sub>5</sub>	R <sub>8</sub>
R <sub>3</sub>	x	R <sub>6</sub>	R <sub>9</sub>

# WEIBULL DISTRIBUTION

CODE	KEYS		CODE	KEYS	7	CODE	KEYS
23	LBL		35 24	g x>y	1	35 01	g NOP
11			00			35 01	g NOP
33 02			81	÷		35 01	g NOP
35 07			31	f		35 01	g NOP
33 01			07	LN	1	35 01	g NOP
24		1	34 01	RCL 1		35 01	g NOP
23			81	÷		35 01	g NOP
12	_		42	_		35 01	g NOP
33 03			34 02	RCL 2		35 01	g NOP
34 02		1	35	g		35 01	g NOP
35	g y <sup>x</sup>		04	<sup>ī</sup> /x		35 01	g NOP
05			35	g		35 01	g NOP
34 01	RCL 1		05	y ×		35 01	g NOP
71	X		24	RTN		35 01	g NOP
42	CHS		35 01	g NOP		35 01	g NOP
32	f <sup>-1</sup>		35 01	g NOP	<b>i</b> i	35 01	g NOP
07	LN		35 01	g NOP		35 01	g NOP
33 04	STO 4		35 01	g NOP		35 01	g NOP
35 00	g LST X		35 01	g NOP		35 01	g NOP
42	CHS		35 01	g NOP		35 01	g NOP
34 03	RCL 3		35 01	g NOP		35 01	g NOP
81	÷		35 01	g NOP	1	35 01	g NOP
71	×		35 01	g NOP		35 01	g NOP
34 02	RCL 2		35 01	g NOP		35 01	g NOP
71	x		35 01	g NOP		35 01	g NOP
24	RTN		35 01	g NOP		35 01	g NOP
23	LBL		35 01	g NOP		35 01	g NOP
13	С		35 01	g NOP		35 01	g NOP
34 04	RCL 4		35 01	g NOP		35 01	g NOP
24	RTN		35 01	g NOP	I L	35 01	g NOP
23	LBL		35 01	g NOP			
14	D		35 01	g NOP			
41	<b>↑</b>		35 01	g NOP			
01	1		35 01	g NOP			
35 07	g x <b></b> ₹y	L	35 01	g NOP			

R <sub>1</sub>	а	R <sub>4</sub>	Q(x)	R <sub>7</sub>	
R <sub>2</sub>	b	R <sub>5</sub>		R <sub>8</sub>	
R <sub>3</sub>	x	R <sub>6</sub>		R <sub>9</sub>	Used

## **BINOMIAL DISTRIBUTION**

CODE	KEYS		CODE	KEYS		CODE	KEYS
23	LBL		00	0	]	61	+
11	A		33 07	STO 7		05	5
33 01	STO 1		35 23	g x=y		34 07	RCL7
35 07	g x <b></b> ≩y		34 03	RCL 3		01	1
33 02	STO 2		24	RTN	ł	61	+
33 04	STO 4		44	CLX	ļ	33 07	STO 7
01	1		34 01	RCL 1	1	34 06	RCL 6
51	-		35 07	g x <b></b> ≩y	ļ	35 23	g x=y
42	CHS		35 24	g x>γ		34 04	RCL 4
34 01	RCL 1		00	0		24	RTN
35	g		81	÷		22	GTO
05	y <sup>x</sup>		32	f <sup>-1</sup>		01	1
33 03	STO 3		83	INT		23	LBL
00	0		00	0		13	С
34 02	RCL 2		35 21	g x≠γ		34 06	RCL 6
35 22	g x≤y		00	0	1	00	0
00	Ō		81	÷		35 23	g x=y
81	÷		34 03	RCL 3		34 03	RCL 3
01	1		33 04	STO 4		24	RTN
34 02	RCL 2	ľ	33 05	STO 5		01	1
51	—		23	LBL	ļ	34 05	RCL 5
81	÷		01	1		35 24	g x>y
33 02	STO 2		34 01	RCL 1		35 07	g x <b></b> ₹y
34 01	RCL 1		34 07	RCL 7		35 01	g NOP
34 04	RCL 4		51	-		24	RTN
71	x		34 07	RCL 7		35 01	g NOP
24	RTN		01	1		35 01	g NOP
01	1		61	+		35 01	g NOP
34 04	RCL 4		81	÷		35 01	g NOP
51	-		34 02	RCL 2		35 01	g NOP
71	x		71	x	1		
84	R/S	1	34 04	RCL 4			
23	LBL		71	x			
12		1	33 04	STO 4			
33 06	STO 6		33	STO			

R <sub>1</sub>	n	R <sub>4</sub>	Used	R <sub>7</sub>	Counter
R <sub>2</sub>	p, p/(1 – p)	R <sub>5</sub>	Used	R <sub>8</sub>	
R <sub>3</sub>	f(0)	R <sub>6</sub>	x	R <sub>9</sub>	Used

## **NEGATIVE BINOMIAL DISTRIBUTION**

CODE	KEYS	]	CODE	KEYS	]	CODE	KEYS
23	LBL	]	35 23	g x=y	1	34 04	RCL 4
11	A		34 03	RCL 3		24	RTN
33 01	STO 1		24	RTN		22	GTO
35 07	g x <b></b> ≩y		35 07	g x <b></b> ₹y		01	1
33 02	STO 2		32	f <sup>-1</sup>		23	LBL
35 07	g x <b></b> ≩y		83	INT		15	E
35	g		35 21	g x≠y		34 06	RCL6
05	y x		00	0		00	0
33 03	STO 3		81	÷		35 23	g x=y
01	1		34 03	RCL 3		34 03	RCL 3
34 02	RCL 2		33 04	STO 4		24	RTN
35 23	g x=y		33 05	STO 5		01	1
00	0		23	LBL		34 05	RCL 5
81	÷		01	1		35 24	g x>y
24	RTN		01	1		35 07	g x <b></b> ₹y
23	LBL		34 02	RCL 2		35 01	g NOP
12	В		51	_		24	RTN
34 01	RCL 1		34 07	RCL 7		35 01	g NOP
34 02	RCL 2		34 01	RCL 1		35 01	g NOP
81	÷		61	+		35 01	g NOP
01	1		71	x		35 01	g NOP
34 02	RCL 2		34 07	RCL 7		35 01	g NOP
51	-		01	1		35 01	g NOP
71	x		61	+		35 01	g NOP
24	RTN	1	33 07	STO 7		35 01	g NOP
23	LBL		81	÷		35 01	g NOP
13	C		34 04	RCL 4		35 01	g NOP
34 02	RCL 2		71	x		35 01	g NOP
81	÷		33 04	STO 4		35 01	g NOP
24	RTN		33	STO		35 01	g NOP
23	LBL		61	+			
14	D		05	5			
33 06	STO 6		34 07	RCL 7			
00	0		34 06	RCL 6			-
33 07	STO 7		35 23	g x=y			

R <sub>1</sub>	r	R <sub>4</sub>	Used	R <sub>7</sub>	Counter
R <sub>2</sub>	р	R <sub>5</sub>	Used	R <sub>8</sub>	
R <sub>3</sub>	f(0)	R <sub>6</sub>	x	R <sub>9</sub>	Used

### HYPERGEOMETRIC DISTRIBUTION

CODE	KEYS		CODE	KEYS		CODE	KEYS
33 02	STO 2		33 06	STO 6		22	GTO
35 07	gx <b></b> ≩y		00	0		01	1
33 01	STO 1		33 08	STO 8		23	LBL
84	R/S		23	LBL		14	D
23	LBL		01	1		34 06	RCL 6
12	в		34 01	RCL 1		24	RTN
33 03	STO 3		51	_		23	LBL
34 02	RCL 2		34 08	RCL 8		15	E
35	g		34 03	RCL 3		34 01	RCL1
03	n!		51	-		34 03	RCL 3
35 00	g LST X		71	x		71	x
34 03	RCL 3		34 08	RCL 8		34 01	RCL 1
51	_		01	· 1		34 02	RCL 2
35	g		61	+		61	+
03	n!		81	÷		33 08	STO 8
81	÷		35 00	g LST X		81	÷
34 01	RCL 1		34 02	RCL 2	l I	84	R/S
34 02	RCL 2		34 03	RCL 3		34 02	RCL 2
61	+		51	<b>—</b>		71	×
35	g		61	+		34 08	RCL 8
03	n!		81	÷		81	÷
35 00	g LST X		34 05	RCL 5		34 08	RCL 8
34 03	RCL 3		71	×		34 03	RCL 3
51	-		33 05	STO 5		51	. —
35	g		33	STO		71	×
03	n!		61	+	1	34 08	RCL 8
81	÷	1	06	6		01	1
81	÷		34 07	RCL 7		51	-
33 04	STO 4		01	1		81	÷
24	RTN		34 08	RCL 8		24	RTN
23	LBL		61	+			
13	С		33 08	STO 8			
33 07	STO 7		35 23	g x=y			
34 04	RCL 4		34 05	RCL 5			
33 05	STO 5		24	RTN			

R <sub>1</sub>	а	R <sub>4</sub>	f(0)	R <sub>7</sub>	x
R <sub>2</sub>	b	R <sub>5</sub>	Used	R <sub>8</sub> Co	unter, a+b
R <sub>3</sub>	n	R <sub>6</sub>	Used	R <sub>9</sub>	Used

## POISSON DISTRIBUTION

CODE	KEYS		CODE	KEYS	]	CODE	KEYS
23			01	1		35 01	g NOP
11	A		34 01	RCL 1		35 01	g NOP
41	1		34 06	RCL 6		35 01	g NOP
00			01	1		35 01	g NOP
35 07	g x <b></b> ≩y		61	+	1	35 01	g NOP
35 22	g x≤y		81	÷	1	35 01	g NOP
00	0		34 03	RCL 3		35 01	g NOP
81	÷		71	x		35 01	g NOP
33 01	STO 1	1	33 03	STO 3		35 01	g NOP
42	CHS		33	STO		35 01	g NOP
32	f <sup>-1</sup>		61	+		35 01	g NOP
07	LN		04	4		35 01	g NOP
33 02	STO 2		34 06	RCL 6		35 01	g NOP
24	RTN		01	1		35 01	g NOP
23	LBL		61	+		35 01	g NOP
12	B	•	33 06	STO 6		35 01	g NOP
33 05	STO 5		34 05	RCL 5		35 01	g NOP
00	0		35 23	g x=y		35 01	g NOP
33 06	STO 6		34 03	RCL 3		35 01	g NOP
35 24	g x>γ	Í	24	RTN		35 01	g NOP
00	0		22	GTO		35 01	g NOP
81	÷		01	1	i i	35 01	g NOP
35 23	g x=γ		23	LBL		35 01	g NOP
34 02	RCL 2		13	С		35 01	g NOP
24	RTN		34 05	RCL 5		35 01	g NOP
35 07	g x <b></b> ₹y	1	00	0		35 01	g NOP
32	f <sup>-1</sup>		35 23	g x=y		35 01	g NOP
83	INT		34 02	RCL 2		35 01	g NOP
35 21	g x≠y		24	RTN		35 01	g NOP
00	0		01	1		35 01	g NOP
81	÷		34 04	RCL 4			
34 02	RCL 2		35 24	g x>y			
33 03	STO 3		35 07	g x <b></b> ₹y			
33 04	STO 4		35 01	g NOP			
23	LBL		24	RTN			

R <sub>1</sub>	λ	$R_4$	Used	R <sub>7</sub>	
R <sub>2</sub>	f(0)	R <sub>5</sub>	x	R <sub>8</sub>	
R <sub>3</sub>	Used	R <sub>6</sub>	Counter	R <sub>9</sub>	Used

## LINEAR REGRESSION

CODE	KEYS	CODE	KEYS	]	CODE	KEYS
23	LBL	09	9	]	09	$\sqrt{x}$
11	А	71	x		24	RTN
34 06	RCL 6	34 05	RCL 5		23	LBL
34 02	RCL 2	34 04	RCL 4		15	E
34 04	RCL 4	32	f <sup>-1</sup>		34 03	RCL3
71	x	09	$\sqrt{x}$		34 02	RCL 2
34 01	RCL 1	34 01	RCL 1		32	f <sup>-1</sup>
81	÷	81	÷		09	$\sqrt{x}$
51	-	51	_		34 01	RCL1
33	STO	81	÷		81	÷
09	9	24	RTN		51	—
34 03	RCL 3	23	LBL		31	f
34 02	RCL 2	13	C		09	$\sqrt{\times}$
32	f <sup>-1</sup>	41	1		81	÷
09	$\sqrt{x}$	34 07	RCL 7		34 03	RCL 3
34 01	RCL 1	71	x		34 01	RCL 1
81	÷	34 08	RCL 8		81	÷
51		61	+		31	f
81	÷	24	RTN		09	$\sqrt{x}$
33 07	STO 7	23	LBL	1	35 07	g x <b></b> ₹γ
34 04	RCL 4	14	D		71	x
34 07	RCL 7	34 05	RCL 5	1	84	R/S
34 02	RCL 2	34 08	RCL 8		35 00	g LST X
71	x	34 04	RCL 4		24	RTN
51	-	71	×		35 01	g NOP
34 01	RCL 1	51	_		35 01	g NOP
81	÷	34 06	6 RCL 6		35 01	g NOP
33 08	STO 8	34 07	RCL 7		35 01	g NOP
84		71	x		35 01	g NOP
34 07		51		1	35 01	g NOP
24		34 01	RCL 1			
23		02	2 2			
12		51				
34 07		81	÷			
34	RCL	31	f			
L		] [				

R <sub>1</sub>	n	R <sub>4</sub>	Σγί	R <sub>7</sub>	a <sub>1</sub>
R <sub>2</sub>	Σxi	R <sub>5</sub>	Σyi <sup>2</sup>	R <sub>8</sub>	a <sub>0</sub>
R <sub>3</sub>	$\Sigma x_i^2$	R <sub>6</sub>	Σχ <sub>i</sub> γ <sub>i</sub>	R <sub>9</sub>	Used

## **EXPONENTIAL CURVE FIT**

CODE	KEYS		CODE	KEYS	]	CODE	KEYS
23	LBL		34 06	RCL 6	1	09	9
11	A		34 02	RCL 2		71	x
31	f		34 04	RCL 4		34 05	RCL 5
07	LN		71	x		34 04	RCL 4
33 07	STO 7		34 01	RCL 1		32	f <sup>-1</sup>
33	STO		81	÷	1	09	$\sqrt{x}$
61	+		51	-		34 01	RCL 1
04	4		33	STO		81	÷
32	f <sup>-1</sup>		09	9	1	51	_
09	$\sqrt{x}$		34 03	RCL 3		81	÷
33	STO		34 02	RCL 2		24	RTN
61	+		32	f <sup>-1</sup>		23	LBL
05	5		09	√x −		14	D
35 07	g x <b></b> ∠y ′		34 01	RCL 1		41	1
33	STO		81	÷		34 07	RCL 7
61	+		51	-		71	x
02	2	ľ	81	÷		32	f <sup>-1</sup>
32	f <sup>-1</sup>		33 07	STO 7		07	LN
09	$\sqrt{x}$		34 04	RCL 4		34 08	RCL 8
33	STO		34 07	RCL 7		71	x
61	+		34 02	RCL 2		24	RTN
03	3		71	x		35 01	g NOP
35 00	g LST X		51	-		35 01	g NOP
34 07	RCL 7		34 01	RCL 1		35 01	g NOP
71	x		81	÷		35 01	g NOP
33	STO		32	f <sup>-1</sup>		35 01	g NOP
61	+		07	LN		35 01	g NOP
06	6		33 08	STO 8		35 01	g NOP
34 01	RCL 1		84	R/S		35 01	g NOP
01	1		34 07	RCL 7		35 01	g NOP
61	+		24	RTN	L		
33 01	STO 1		23	LBL			
24	RTN		13	C			
23	LBL		34 07	RCL 7			
12	В		34	RCL			
		L					

R <sub>1</sub>	n	R <sub>4</sub>	ΣIny <sub>i</sub>	R <sub>7</sub>	lny <sub>i</sub> , b
R <sub>2</sub>	Σx <sub>i</sub>	R <sub>5</sub>	$\Sigma (\ln y_i)^2$	R <sub>8</sub>	a
R <sub>3</sub>	$\Sigma x_i^2$	R <sub>6</sub>	$\Sigma x_i ln y_i$	R <sub>9</sub>	Used

#### POWER CURVE FIT

CODE	KEYS	]	CODE	KEYS		CODE	KEYS
23	LBL		23	LBL		34 07	RCL 7
11	A		12	В		34	RCL
31	f		34 06	RCL 6		09	9
07	LN		34 02	RCL 2		71	x
33 07	STO 7		34 04	RCL 4		34 05	RCL 5
33	STO		71	x	1	34 04	RCL 4
61	+		34 01	RCL 1		32	f <sup>-1</sup>
04	4		81	÷		09	$\sqrt{x}$
32	f <sup>-1</sup>		51	—		34 01	RCL 1
09	$\sqrt{x}$		33	STO		81	÷
33	STO		09	9		51	-
61	+		34 03	RCL 3		81	÷
05	5		34 02	RCL 2		24	RTN
35 07	g x <b></b> ,∠y		32	f <sup>-1</sup>		23	LBL
31	f	ļ	09	$\sqrt{x}$		14	D
07	LN		34 01	RCL 1		41	1
33	STO		81	÷		34 07	RCL 7
61	+		51	-	1	35	g
02	2		81	÷		05	y <sup>x</sup>
32	f <sup>-1</sup>		33 07	STO 7		34 08	RCL 8
09	$\sqrt{x}$		34 04	RCL 4		71	×
33	STO		34 07	RCL 7		24	RTN
61	+		34 02	RCL 2		35 01	g NOP
03	3		71	x		35 01	g NOP
35 00			51	-		35 01	g NOP
34 07	RCL 7		34 01	RCL 1		35 01	g NOP
71	×		81	÷		35 01	g NOP
33	STO		32	f <sup>-1</sup>		35 01	g NOP
61	+		07	LN		35 01	g NOP
06			33 08			35 01	g NOP
34 01		1	84		1		
01	1		34 07				
61			24				
33 01			23				
24	RTN		13	C			
			L				

R <sub>1</sub>	n	R <sub>4</sub>	Σ In y <sub>i</sub>	R <sub>7</sub>	ln y <sub>i</sub> , b
R <sub>2</sub>	$\Sigma \ln x_i$	R <sub>5</sub>	$\Sigma (\ln y_i)^2$	R <sub>8</sub>	а
R <sub>3</sub>	$\Sigma (\ln x_i)^2$	$R_6$	$\Sigma$ (ln x <sub>i</sub> ) (ln y <sub>i</sub> )	R <sub>9</sub>	Used

#### LOGARITHMIC CURVE FIT

CODE	KEYS	]	CODE	KEYS	7	CODE	KEYS
23	LBL	1	34 06	RCL 6	1	34 05	RCL 5
11	А	1	34 02	RCL 2		34 04	RCL 4
33 07	STO 7		34 04	RCL 4		32	f <sup>-1</sup>
33	STO		71	x		09	$\sqrt{x}$
61	+		34 01	RCL 1		34 01	RCL 1
04	4	1	81	÷		81	÷
32	f <sup>-1</sup>		51	_		51	—
09	$\sqrt{x}$		33	STO		81	÷
33	STO	1	09	9		24	RTN
61	+		34 03	RCL 3		23	LBL
05	5	i i	34 02	RCL 2		14	D
35 07	g x <b></b> ≵y		32	f <sup>-1</sup>		31	f
31	f		09	$\sqrt{x}$		07	LN
07	LN		34 01	RCL 1		34 07	RCL 7
33	STO		81	÷		71	x
61	+		51	_		34 08	RCL 8
02	2		81	÷		61	+
32	f <sup>-1</sup>		33 07	STO 7		24	RTN
09	$\sqrt{x}$		34 04	RCL 4		35 01	g NOP
33	STO		34 07	RCL 7		35 01	g NOP
61	+		34 02	RCL 2		35 01	g NOP
03	3		71	x	[ ]	35 01	g NOP
35 00	g LST X		51	-		35 01	g NOP
34 07	RCL 7		34 01	RCL 1		35 01	g NOP
71	x		81	÷		35 01	g NOP
33	STO		33 08	STO 8		35 01	g NOP
61	+		84	R/S		35 01	g NOP
06	6		34 07	RCL 7		35 01	g NOP
34 01	RCL 1	1	24	RTN		35 01	g NOP
01	1		23	LBL		35 01	g NOP
61	+		13	C			
33 01	STO 1		34 07	RCL 7			
24	RTN		34	RCL			
23	LBL		09	9			
12	В		71	x			

R <sub>1</sub>	n	R <sub>4</sub>	Σγ <sub>i</sub>	R <sub>7</sub>	y <sub>i</sub> , b
<u> </u>	$\Sigma \ln x_i$	<b>R</b> <sub>5</sub>	Σyi²	R <sub>8</sub>	a
R <sub>3</sub>	$\Sigma (\ln x_i)^2$	R <sub>6</sub>	$\Sigma y_i \ln x_i$	R <sub>9</sub>	Used

LEAST SQUARES REGRESSION OF  $y = cx^a + dx^b$ 

CODE	KEYS		CODE	KEYS	]	CODE	KEYS
33 02	STO 2		61	+	]	71	x
35 07	g x <b></b> ,y		05	5		34 06	RCL6
33 01	STO 1		35 08	gR↓		35 07	gx <b></b> ⊄γ
24	RTN		32	f <sup>-1</sup>		51	-
23	LBL		09	$\sqrt{x}$	-	34 08	RCL8
12	В		33	STO		81	÷
35 07	g x <b></b> ₹y		61	+		33	STO
33 03	STO 3		08	8		09	9
34 01	RCL 1		34	RCL		24	RTN
35	g		09	9		34 03	RCL 3
05	y <sup>x</sup>		32	f <sup>-1</sup>		84	R/S
41	1		09	$\sqrt{x}$		23	LBL
41	1		33	STO		14	D
35 09	g R1		61	+		41	↑
71	x	l	07	7		41	1
33	STO		24	RTN		34 01	RCL 1
61	+		23	LBL		35	g
06	6		13	C		05	y <sup>x</sup>
44	CLX		34 08	RCL 8		34	RCL
35 00	g LST X		34 04	RCL 4		09	9
34 03	RCL 3		71	x		71	×
34 02	RCL 2		34 06	RCL 6		35 07	g x <b></b> ₹y
35	9		34 05	RCL 5		34 02	RCL 2
05	y ×		71	x	1	35	g y <sup>x</sup>
33	STO		51	-		05	
09	9		34 07	RCL 7		34 03	RCL 3
71	×		34 08	RCL 8		71	× +
33	STO		71	X		61	1
61	+		34 05	RCL 5		24	RTN g NOP
04	4		32	f <sup>-1</sup>		35 01	U NOF
44	CLX		09	$\sqrt{x}$	1		
34	RCL		51	-			
09	9	1	81	÷			
71	x		33 03	STO 3	1		
33	STO		34 05	RCL 5			

R <sub>1</sub>	а	R <sub>4</sub>	Σyixip	R <sub>7</sub>	Σxi <sup>2b</sup>
R <sub>2</sub>	b	R <sub>5</sub>	Σxi <sup>a+b</sup>	R <sub>8</sub>	∑xi <sup>2a</sup>
R <sub>3</sub>	x <sub>i</sub> , d	R <sub>6</sub>	Σxi <sup>a</sup> λi	R <sub>9</sub>	xi <sup>b</sup> , c

#### MULTIPLE LINEAR REGRESSION (CARD 1)

CODE	KEYS	]	CODE	KEYS	]	CODE	KEYS
23	LBL	]	71	x	1	51	_
11	А		33	STO		04	4
41	1		61	+		44	CLX
35 08	gR↓		01	1		35 00	g LST X
33	STO		44	CLX		35 07	gx, <b></b> Ży
61	+		35 00	g LST X		33	STO
09	9		71	x		51	_
35 07	g x컱y		33	STO		07	7
71	x		61	+		32	f <sup>-1</sup>
33	STO		02	2		09	$\sqrt{x}$
61	+		01	1		33	STO
03	3		34 05	RCL 5		51	-
44	CLX		61	+		06	6
35 00	g LST X		33 05	STO 5		44	CLX
33	STO		24	RTN		35 00	g LST X
61	+		23	LBL		71	x
08	8		12	В		33	STO
32	f <sup>-1</sup>		41	1		51	-
09	√x		35 08	gR↓		01	1
33	STO		33	STO		44	CLX
61	+		51	_		35 00	g LST X
04	4		09	9		71	x
44	CLX		35 07	g x <b></b> ≩y		33	STO
35 00	g LST X		71	x		51	- (
35 07	g x <b></b> ∠y	- 1	33	STO		02	2
33	STO		51	-		34 05	RCL 5
61	+		03	3		01	1
07	7		44	CLX		51	-
32	f <sup>-1</sup>		35 00	g LST X		33 05	STO 5
09	$\sqrt{x}$		33	STO		24	RTN
33	STO		51	-	-		
61	+		08	8			
06	6		32	f <sup>-1</sup>			
44	CLX		09	$\sqrt{x}$			
35 00	g LST X		33	STO			
		L					

R <sub>1</sub>	Σχ <sub>i</sub> γ <sub>i</sub>	R <sub>4</sub>	$\Sigma \gamma_i^2$	R <sub>7</sub>	Σxi
R <sub>2</sub>	Σx <sub>i</sub> z <sub>i</sub>	R <sub>5</sub>	n	R <sub>8</sub>	Σγι
R <sub>3</sub>	Σy <sub>i</sub> z <sub>i</sub>	R <sub>6</sub>	Σx <sub>i</sub> <sup>2</sup>	R <sub>9</sub>	Σzi

## MULTIPLE LINEAR REGRESSION (CARD 2)

CODE	KEYS	ſ	CODE	KEYS		CODE	KEYS
23	LBL		51			34 02	RCL 2
11	A		33 02	STO 2		34 07	RCL 7
34 05	RCL 5		71	x		71	×
34 06	RCL 6		34 03	RCL 3		51	-
71	x		35 07	g x <b></b> ∠y		34 05	RCL 5
34 07	RCL 7		51	_		81	÷
32	f <sup>-1</sup>		34 06	RCL 6	1	33 01	STO 1
09	$\sqrt{x}$	l ì	34 05	RCL 5		84	R/S
51	-		34 04	RCL 4		23	LBL
33 06	STO 6		71	x	Į	12	В
34 05	RCL 5		34 08	RCL 8		34 02	RCL 2
34 03	RCL 3		32	f <sup>-1</sup>	1	84	R/S
71	x		09	$\sqrt{x}$		23	LBL
34 08	RCL 8	1	51	-		13	С
34	RCL		71	x		34 03	RCL 3
09	9		34 01	RCL 1	1	84	R/S
71	· <b>x</b>		32	f <sup>-1</sup>		23	LBL
51	-		09	$\sqrt{x}$		14	D
71	x	1	51	-		41	1
33 03	STO 3	1	81	÷		34 03	RCL 3
34 05	RCL 5	1	33 03	STO 3	1	71	X
34 01	RCL 1		34 02	RCL 2	1	35 07	g x <b></b> ₹γ
71	×		34 01	RCL 1		34 02	RCL 2
34 07	RCL 7	1	34 03	RCL 3		71	x
34 08			71	x		61	+
71	x		51	-		34 01	RCL 1
51	-	1	34 06			61	+
33 01	STO 1		81	÷		24	
34 05	RCL 5		33 02			35 01	
34 02		1	34			35 01	g NOP
71			09		1		
34 07	RCL 7		34 03				
34			34 08		1		
09			71				
71	1		51	-			

R <sub>1</sub>	Used	R <sub>4</sub>	$\Sigma \gamma_i^2$	R <sub>7</sub>	Σxi
R <sub>2</sub>	Used	R <sub>5</sub>	n	R <sub>8</sub>	Σyi
R <sub>3</sub>	Used	<b>R</b> <sub>6</sub> Σ	$x_i^2$ , $n\Sigma x_i^2 - (2$	$(\Sigma_{x_i})^2 \mathbf{R_9}$	Σzi

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#### **PARABOLIC CURVE FIT**

CODE			CODE	KEYS	7	C	DDE	KEYS
23	LBL	7	61	+	1		71	×
11	1		04	4			33	STO
33	STO		34 05	RCL 5		1	51	_
61	+		01	1	1		01	1
09	9		61	+		35	00	g LST X
35 07		í	33 05	STO 5		1	71	x
33	STO		24	RTN			33	STO
61	+		23	LBL			51	
07	7	1	12	В			04	4
71	X		33	STO	ĺ	34	05	RCL 5
33	STO		51	-			01	1
61	+		09	9	1		51	
02	2		35 07	g x <b></b> ≩y		33	05	STO 5
35 00	g LST X		33	STO			24	RTN
71	X		51	-			23	LBL
33	STO		07	7			13	С
61	+		71	x			04	STO 4
03	3		33	STO		34		RCL 3
35 00	g LST X f <sup>-1</sup>		51	-			71	x
32			02	2		34		RCL 2
09 33	$\sqrt{x}$		35 00	g LST X			61	+
61	STO		71	x		34		RCL 4
06	+ 6		33	STO			71	x
33	-		51	_		34		RCL 1
61	STO	[ ]	03	3			61	+
08	+ 8		35 00	g LST X			24	RTN
35 00	o g LST X		32	f-1		35		g NOP
33 00 71	-		09	$\sqrt{x}$		35		g NOP
33	x STO		33	STO		35		g NOP
61			51	-		35	01	g NOP
01	1		06	6 STO		_		
35 00	g LST X		33 51	STO				
71	x		08	8				
33	ŝто		35 00	-				
		L	55 00	g LST X				

R <sub>1</sub>	$\Sigma x_i^3$ , $a_0$	R <sub>4</sub>	$\Sigma x_i^4$ , x	R <sub>7</sub>	Σxi
R <sub>2</sub>	Σx <sub>i</sub> y <sub>i</sub> , a <sub>1</sub>	$R_5$	n	R <sub>8</sub>	$\Sigma x_i^2$
R <sub>3</sub>	$\Sigma x_i^2 y_i, a_2$	R <sub>6</sub>	$\Sigma x_i^2$	R <sub>9</sub>	Σγί

#### PAIRED t STATISTIC

CODE	KEYS		CODE	KEYS		CODE	KEYS
23	LBL		51			24	RTN
11	A		34 01	RCL 1		35 01	g NOP
00	0		01	1		35 01	g NOP
33 01	STO 1		51	-	1	35 01	g NOP
33 02	STO 2		81	÷		35 01	g NOP
33 03	STO 3		31	f		35 01	g NOP
24	RTN	1	09	$\sqrt{x}$	1	35 01	g NOP
23	LBL		24	RTN		35 01	g NOP
12	в	ĺ	23	LBL		35 01	g NOP
51	-		14	D	1	35 01	g NOP
33	STO		34 01	RCL 1		35 01	g NOP
61	+		31	f		35 01	g NOP
02	2		09	√x		35 01	g NOP
32	f <sup>-1</sup>		81	÷		35 01	g NOP
09	$\sqrt{x}$		81	÷		35 01	g NOP
33	STO		84	R/S	1	35 01	g NOP
61	+	l.	34 01	RCL 1		35 01	g NOP
03	3		01	1		35 01	g NOP
34 01	RCL 1		51	-		35 01	g NOP
01	1		24	RTN		35 01	g NOP
61	+		23	LBL	1	35 01	g NOP
33 01	STO 1		15	E		35 01	g NOP
24	RTN		51			35 01	g NOP
23	LBL		33	STO	1	35 01	g NOP
13	С		51	-		35 01	g NOP
34 02	RCL 2		02	2		35 01	g NOP
34 01	RCL 1		32	f <sup>-1</sup>		35 01	g NOP
81	÷		09	$\sqrt{x}$		35 01	g NOP
84	R/S		33	STO		35 01	g NOP
34 03	RCL 3		51	-		35 01	g NOP
34 02		1	03	3			
32	f <sup>-1</sup>		34 01	RCL 1	1		
09			01	1			
34 01	RCL 1		51	-			
81	÷		33 01	STO 1			
			L	<u> </u>	<b>_</b> _		

R <sub>1</sub>	n	R <sub>4</sub>	R <sub>7</sub>
R <sub>2</sub>	ΣDi	R <sub>5</sub>	R <sub>8</sub>
R <sub>3</sub>	ΣDi <sup>2</sup>	R <sub>6</sub>	R <sub>9</sub>

### t STATISTIC FOR TWO MEANS

CODE		]	CODE	KEYS	]	CODE	KEYS
2:	3 LBL	7	14	D	1	34 05	RCL 5
1	1   A	1	34 06	RCL 6		34 04	
0		1	34 05			81	÷
33 0			32			34 02	RCL 2
33 02		1	09	$\sqrt{x}$	}	34 01	RCL 1
33 03		1	34 04			81	÷
24			81	÷		51	
23	-		51	-	1	34 07	RCL 7
12			34 03	RCL 3		51	_
33			61	+	1	35 07	gx <b></b> ≩y
61			34 02	RCL 2		81	÷
02		1 1	32	.f <sup>-1</sup>	[	84	R/S
32			09	$\sqrt{x}$	1	34 08	RCL 8
09	• • •		34 01	RCL 1		24	RTN
33	-		81	÷		23	LBL
61		·	51	-		15	E
03			34 01	RCL 1		33	STO
34 01	RCL 1		34 04	RCL 4		51	-
01	1 +		61	+		02	2
33 01			02	2		32	f <sup>-1</sup>
24	STO 1 RTN		51	-		09	$\sqrt{x}$
24	LBL		33 08	STO 8		33	STO
13	С		81	÷		51	- [
33 07	STO 7		31	f		03	3
84	R/S		09	$\sqrt{x}$		34 01	RCL 1
34 01	RCL 1		01			01	1
33 04	STO 4		34 01	RCL 1		51	_
34 02	RCL 2		81	÷		33 01	STO 1
33 05	STO 5		01 34 04			24	RTN
34 03	RCL 3		34 04 81	RCL 4 ÷	L	35 01	g NOP
33 06	STO 6		61	+			
11	A		31	f			
24	RTN		09	√x			
23	LBL		71	x x			
		L					

R <sub>1</sub>	n <sub>1</sub> , n <sub>2</sub>	R <sub>4</sub>	n <sub>1</sub>	R <sub>7</sub>	D
	Σχ <sub>i</sub> , Σγ <sub>i</sub>	R <sub>5</sub>	Σx <sub>i</sub>	R <sub>8</sub>	$n_1 + n_2 - 2$
R <sub>3</sub>	$\Sigma x_i^2$ , $\Sigma y_i^2$	R <sub>6</sub>	Σxi <sup>2</sup>	R <sub>9</sub>	

#### CHI-SQUARE EVALUATION

CODE	KEYS	1	CODE	KEYS		CODE	KEYS
00	0		01	1	1	15	E
33 01	STO 1		51			31	f
33 02	STO 2		33 01	STO 1	1	61	TF 1
33 03	STO 3		24	RTN		22	GTO
32	$f^{-1}$		23	LBL	1	01	1
51	SF 1		13	С	1	34 02	RCL 2
84	R/S		33	STO	1	24	RTN
23	LBL		61	+		23	LBL
11	A		02	2		01	1
33 03	STO 3	Į	32	f <sup>-1</sup>		34 01	RCL 1
51	_		09	$\sqrt{x}$		34 03	RCL 3
32	f <sup>-1</sup>		33	STO		71	x
09	$\sqrt{x}$	ļ	61	+		34 02	RCL 2
34 03	RCL 3		03	3		81	÷
81	÷	1	34 01	RCL 1		34 02	RCL 2
33	STO	1	01	1		51	-
61	+		61	+		84	R/S
02	2		33 01	STO 1		34 02	RCL 2
34 01	RCL 1	1	24	RTN		34 01	RCL 1
01	1	Ì	23	LBL		81	÷
61	+		14	D		24	RTN
33 01	STO 1		33	STO		35 01	g NOP
24	RTN		51	-		35 01	g NOP
23	LBL		02	2		35 01	g NOP
12	В		32	f <sup>-1</sup>		35 01	g NOP
33 03	STO 3		09	$\sqrt{x}$		35 01	g NOP
51	_		33	STO		35 01	g NOP
32	f <sup>-1</sup>		51			35 01	g NOP
09			03	3		35 01	g NOP
34 03			34 01	RCL 1		35 01	g NOP
81			01	1			
33			51				
51			33 01				
02			24				
34 01			23	LBL			

R <sub>1</sub>	n –	R <sub>4</sub>	R <sub>7</sub>
R <sub>2</sub>	Used	R <sub>5</sub>	R <sub>8</sub>
$R_3$	Used	R <sub>6</sub>	R <sub>9</sub>

## 2 x k CONTINGENCY TABLE

CODE	KEYS		COD	E	KEYS		C	DDE	KEYS	٦
23	LBL		C	)5	5	-		01	1	┥
11	А		35 C		gR↓			51	1	
31	f		34 0	8	RCL 8			24	RTN	
43	REG		4	1	1			23	LBL	
24	RTN		7	1	x			15	E	
23	LBL		35 0	7	g x <b></b> ≩y		34	07	RCL 7	
12	В		8	1	÷			04	RCL 4	1
33 08	STO 8		3	3	STO			07	RCL 7	
35 07	g x <b></b> ≵y		6	1	+			61	+	
33 07	STO 7		0	6	6			81	÷	
41	↑		0		1	1		31	f	
41	↑		34 03		RCL 3			09	√x	
71	×		6		+	1		24	RTN	
35 08	g R↓		33 03		STO 3		35	01	g NOP	
33	STO		24		RTN	1	35		g NOP	
61	+		23		LBL		35	01	g NOP	
01 33	1	1	13		С	1	35	01	g NOP	
61	STO		34 04		RCL 4		35	01	g NOP	
	+ 4		34 05	1	RCL 5		35	01	g NOP	i I
			71		x		35	01	g NOP	
	g x <b></b> Ży STO		34 01	F	RCL 1		35		g NOP	
	+		81		÷		35 (		g NOP	
	2		34 04		RCL 4		35 (		g NOP	
	STO		34 06 34 02	1	RCL 6		35 (		g NOP	
	+	1	- • •=		RCL 2		35 (		g NOP	
1	4		81	1	÷		35 (		g NOP	
	+		71	1	×		35 C		g NOP	
1	t		61 34 04	1			35 C		g NOP	
	RI	1.			RCL 4	- 1	35 0	1 .	g NOP	
	ix <b>≵</b> y		51 33 07			L	35 0	)1 [	NOP	
	R↓		24							
81 ÷			24							
	то		23 14	Ľ	BL					
61 +	-	13	4 03	-	RCL 3					
		Ľ	- 03							

R <sub>2</sub> N	P	R <sub>5</sub>	2 /21		a <sub>i</sub> , χ*
	0	' <b>'</b> 5	$\Sigma a_i^2/N_i$	R <sub>8</sub>	b:
R <sub>3</sub> k		R <sub>6</sub>	$\Sigma b_i^2/N_i$		0

### BARTLETT'S CHI-SQUARE STATISTIC

CODE	KEYS		CODE	KEYS		CODE	KEYS
23	LBL		33 05	STO 5		51	-
11	A		24	RTN	1	03	3
31	f		23	LBL		35	g
43	REG	ļ	13	С		04	<sup>1</sup> /x
24	RTN	ļ	34 08	RCL 8	1	33	STO
23	LBL		34 03	RCL 3	1	51	-
12	В		81	÷		04	4
33 01	STO 1	1	31	f		35 08	gR↓
33	STO		07	LN		41	1
61	+		34 03	RCL 3		41	1
03	3		71	x		34 01	RCL 1
35	g		34 07	RCL 7	1	71	x
04	1/x	1	51	·	1	33	STO
33	STO		34 04	RCL 4		51	-
61	+		34 03	RCL 3		08	8
04	4		35	g		35 07	g x <b></b> ₹y
35 08	gR↓		04	<sup>1</sup> /x		31	f
41	1		51	-		07	LN
41	1		34 05	RCL 5		34 01	RCL 1
34 01	RCL 1		01	1		71	X
71	×		51	-		33	STO
33	STO		33 02			51	
61	+		03	3	1	07	7
08			71	x	1	34 05	RCL 5
35 07	g x <b></b> ₹γ		81	÷		01	1
31	f		01	1		51	STO 5
07			61	+		33 05	
34 01			81	÷		24	
71			84			35 01	
33			34 02			35 01	g NOP
61			24				
07			23				
34 05			14				
01			33 01				
6	1 +		33	STO			

R <sub>1</sub>	fi	R <sub>4</sub>	Σ1/f <sub>i</sub>	R <sub>7</sub>	$\Sigma f_i \ln s_i^2$
R <sub>2</sub>	df	R <sub>5</sub>	k	R <sub>8</sub>	$\Sigma f_{i} s_{i}^{2}$
R <sub>3</sub>	Σfi	R <sub>6</sub>	0	R <sub>9</sub>	0

## SPEARMAN'S RANK CORRELATION COEFFICIENT

CODE	KEYS	]	CODE	KEYS	]	CODE	KEYS
23	LBL	7	23	LBL	1	35 01	g NOP
11	A		14	D		35 01	g NOP
00	0		34 01	RCL 1		35 01	g NOP
33 01	STO 1		01	1		35 01	g NOP
33 02	STO 2		51	_		35 01	g NOP
24	RTN		31	f		35 01	g NOP
23	LBL		09	$\sqrt{x}$		35 01	g NOP
12	В		71	x		35 01	g NOP
51			24	RTN		35 01	g NOP
32	f <sup>-1</sup>		23	LBL		35 01	g NOP
09	$\sqrt{x}$		15	E		35 01	g NOP
33	STO		51			35 01	g NOP
61	+		32	f <sup>-1</sup>		35 01	g NOP
02	2		09	$\sqrt{x}$		35 01	g NOP
34 01	RCL 1		33	STO		35 01	g NOP
01	1	· ·	51	_		35 01·	g NOP
61	+		02	2		35 01	g NOP
33 01	STO 1		34 01	RCL 1		35 01	g NOP
24	RTN		01	1		35 01	g NOP
23 13	LBL		51			35 01	g NOP
	C 1		33 01	STO 1		35 01	g NOP
01	-		24	RTN		35 01	g NOP
34 02 06	RCL 2		35 01	g NOP		35 01	g NOP
71	6		35 01	g NOP		35 01	g NOP
34 01	X RCL 1		35 01	g NOP		35 01	g NOP
34 01	f <sup>-1</sup>		35 01	g NOP		35 01	g NOP
09	$\sqrt{x}$		35 01	g NOP		35 01	g NOP
09	$\frac{\sqrt{x}}{1}$	1	35 01	g NOP		35 01	g NOP
51	·	1	35 01	g NOP		35 01	g NOP
34 01	RCL 1		35 01	g NOP	Ĺ	35 01	g NOP
71	x		35 01 35 01	g NOP			_
81	÷		35 01	g NOP			
51	·		35 01	g NOP			
24	RTN		35 01	g NOP			
		L		g NOP			

R <sub>1</sub>	n	R <sub>4</sub>	R <sub>7</sub>
R <sub>2</sub>	$\Sigma D_i^2$	R <sub>5</sub>	R <sub>8</sub>
R <sub>3</sub>		R <sub>6</sub>	R <sub>9</sub>

#### MANN-WHITNEY STATISTIC

CODE	KEYS		CODE	KEYS		CODE	KEYS
23	LBL		02	2	1	35 01	g NOP
11	A		81	÷	1	35 01	g NOP
33 02	STO 2		51	-		35 01	g NOP
00	0		34 01	RCL 1	ļ	35 01	g NOP
33 01	STO 1		34 02	RCL 2		35 01	g NOP
33 03	STO 3		61	+	Ì	35 01	g NOP
24	RTN		01	1		35 01	g NOP
23	LBL		61	+	1	35 01	g NOP
12	в		34 01	RCL 1		35 01	g NOP
33	STO		71	x		35 01	g NOP
61	+	ļ	34 02	RCL 2	1	35 01	g NOP
03	3		71	x	1	35 01	g NOP
34 01	RCL 1		01	1	1	35 01	g NOP
01	1		02	2		35 01	g NOP
61	+		81	÷		35 01	g NOP
33 01	STO 1		31	f		35 01	g NOP
24	RTN		09	$\sqrt{x}$		35 01	g NOP
23	LBL		81	÷		35 01	g NOP
13	С		24	RTN		35 01	g NOP
34 02	RCL 2		23	LBL		35 01	g NOP
34 01	RCL 1		15	E		35 01	g NOP
01	1		33	STO		35 01	g NOP
61	+		51	-		35 01	g NOP
02	2		03	3		35 01	g NOP
81	÷		34 01	RCL 1		35 01	g NOP
61	+		01	1		35 01	g NOP
71	x		51	_		35 01	g NOP
34 03	RCL 3		33 01	STO 1		35 01	g NOP
51	-		24	RTN		35 01	g NOP
24	RTN		35 01	g NOP		35 01	g NOP
23	LBL		35 01	g NOP			
14	D		35 01	g NOP			
34 01		1	35 01	g NOP			
34 02	RCL 2		35 01	g NOP			
71	x		35 01	g NOP			
	<u> </u>		L				

R <sub>1</sub>	n <sub>1</sub>	R <sub>4</sub>	R <sub>7</sub>
R <sub>2</sub>	n <sub>2</sub>	R <sub>5</sub>	R <sub>8</sub>
R <sub>3</sub>	$\Sigma R_i$	R <sub>6</sub>	R <sub>9</sub>

# KENDALL'S COEFFICIENT OF CONCORDANCE

COD	E KEYS	- - - -	CODE	KEYS	7	CODE	KEYS
0		-1 F	23	LBL	-	51	+
33 0			13	C		71	×
33 0			34 03	RCL 3		84	R/S
33 0:			01	1		34 04	RCL 4
33 04			02	2		01	1
84			71	x		51	
23		3	84 05	RCL 5		24	RTN
11			32	f <sup>-1</sup>		23	LBL
33			09	$\sqrt{x}$		15	E
61			81	÷		33	STO
02		3	4 04	RCL 4		51	_
34 01	RCL 1		81	÷ '		02	2
01	1	3	4 04	RCL 4		34 01	RCL 1
61	+		32	f <sup>-1</sup>		01	1
33 01	STO 1		09	$\sqrt{x}$		51	_
24	RTN		01	1		33 01	STO 1
23	LBL		51	-		24	RTN
12	B		81	÷		35 01	g NOP
34 01 33 05	RCL 1	34		RCL 4	:	35 01	g NOP
34 02	STO 5		01	1	:	35 01	g NOP
34 02	RCL 2 f <sup>-1</sup>		61	+	:	35 01	g NOP
09	$\sqrt{x}$		1	3	:	/	g NOP
33				x		35 01	g NOP
61	STO +	34	1	RCL 4			g NOP
03	3			1			g NOP
34 04	RCL 4		51	-			g NOP
01	1 1			÷			g NOP
61	+		51	-			g NOP
33 04	STO 4			RTN			J NOP
00	0		1	LBL	3	501 g	NOP
33 01	STO 1		1				
33 02	STO 2	34		RCL 5			
34 04	RCL 4		1				
24	RCL 4	34		RCL 4			
	IT IN		01   1				
		•					

1	R <sub>4</sub>	n	R <sub>7</sub>
$\Sigma R_{ij}$	R <sub>5</sub>	k	R <sub>8</sub>
$\Sigma (\Sigma R_{ij})^2$	R <sub>6</sub>		R <sub>9</sub>
		<u> </u>	$\Sigma R_{ij}$ $R_5$ k

### BISERIAL CORRELATION COEFFICIENT

CODE	KEYS	[	CODE	KEYS		CODE	KEYS
23	LBL		01	1		35 01	g NOP
11	A		61	+		35 01	g NOP
31	f		33 03	STO 3		35 01	g NOP
43	REG		24	RTN		35 01	g NOP
33 01	STO 1		23	LBL		35 01	g NOP
24	RTN		14	D		35 01	g NOP
23	LBL		34 04	RCL 4		35 01	g NOP
12	В		33	STO	1	35 01	g NOP
33	STO	ļ	61	+	1	35 01	g NOP
61	+	1	05	5	1	35 01	g NOP
04	4		34 03	RCL 3	1	35 01	g NOP
32	f <sup>-1</sup>		71	x	1	35 01	g NOP
09	$\sqrt{x}$		34 05	RCL 5		35 01	g NOP
33	sто		34 02	RCL 2		35 01	g NOP
61	+	1	71	x		35 01	g NOP
06	6	1	51	-		35 01	g NOP
01	1		34 03	RCL 3		35 01	g NOP
33	STO		81	÷		35 01	g NOP
61	+		34 01	RCL 1		35 01	g NOP
02	2	1	81	÷	1	35 01	g NOP
34 03	RCL 3		34 03	RCL 3		35 01	g NOP
61	+	1	34 06	RCL 6		35 01	g NOP
33 03	STO 3		71	x		35 01	g NOP
24	RTN		34 05	RCL 5		35 01	g NOP
23	LBL		32	f <sup>-1</sup>		35 01	g NOP
13	C		09	$\sqrt{x}$		35 01	g NOP
33	STO		51	-		35 01	g NOP
61	+		31	f_	1	35 01	
05			09			35 01	
32			81			35 01	g NOP
09			24				
33			35 01				
61			35 01				
06			35 01				
34 03	B RCL 3		35 01	g NOP			

R <sub>1</sub>	a	R <sub>4</sub>	$\Sigma' \gamma_i$	R <sub>7</sub>	0	
R <sub>2</sub>	n <sub>1</sub>	R <sub>5</sub>	Σγι	R <sub>8</sub>	0	
$R_3$	 n	R <sub>6</sub>	$\Sigma \gamma_i^2$	R <sub>9</sub>	0	



Same<sup>r</sup>

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