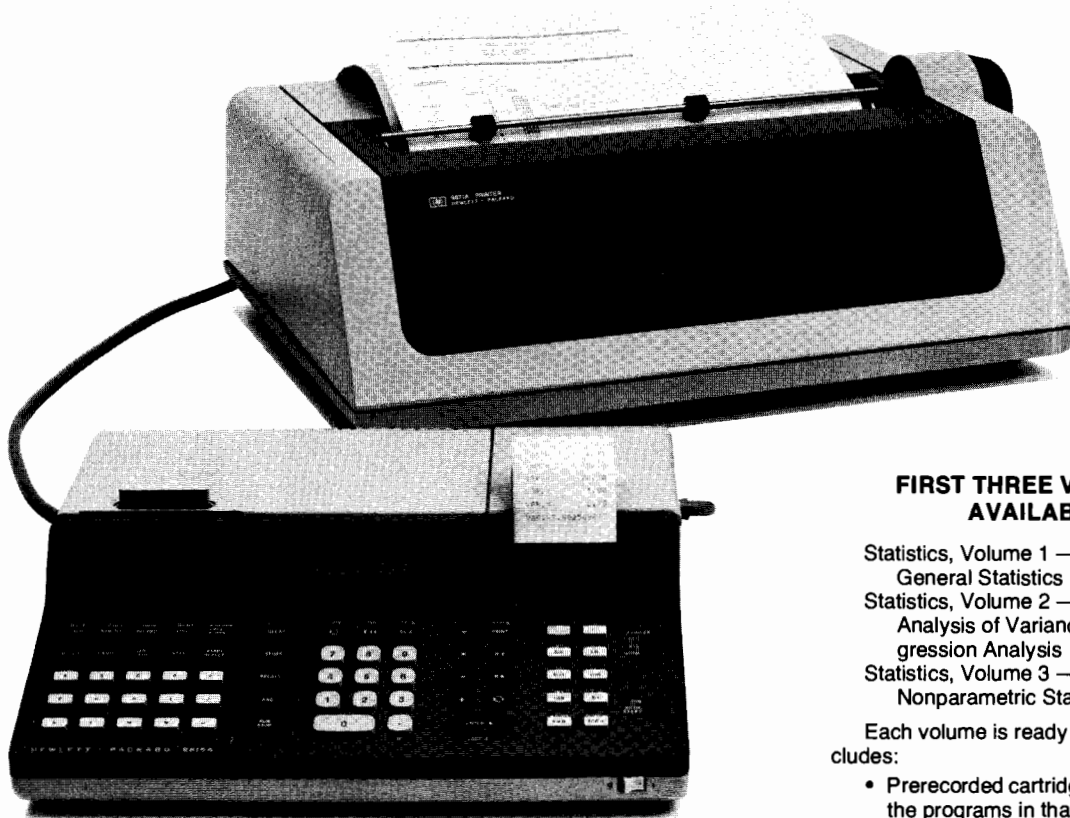


Summary Calculator Application Summary Calculator App



HP 9815A Programmable Calculator and HP 9871A Printer.

HP 9815 — THE LATEST STATISTICAL ANSWER

Whatever your vocation: chemist, biologist, psychologist, or statistician; whatever your concern: process control, manufacturing yield, or pure research, the HP 9815A Programmable Calculator is your statistical answer. The 9815 gives you power and flexibility at an economical price. The built-in, high-speed data cartridge provides fast storage and retrieval of data. The 16-character, alphanumeric, thermal printer gives you quiet, readable results at 28 lines per second.

The 9815's simplified programming language, along with powerful editing features, permits you to dedicate it to do exactly the calculations you need in addition to all of the available statistical solutions. Consider the background and experience that has led to the 9815's statistics library.

YEARS OF EXPERIENCE

The 9815 statistics software library is the result of a cooperative effort between a major university and Hewlett-Packard. Several years ago, a professor with this university's statistical laboratory wrote several of his own statistical analysis programs with HP's first desk-top programmable calculator. Hewlett-Packard published these programs with his permission and there was an overwhelming demand for more of these flexible statistical programs. It was his applied experience that came from solving all types of problems in many different disciplines, as well as statistical knowledge, that gave the first HP statistical library its uniquely useful character. This relationship flourished and now, Hewlett-Packard, through a grant with this university, has almost all of its statistical programs on each programmable calculator developed by him and the people he directs. This professor has since become director and turned his group of people into one of the largest and most highly regarded statistical laboratories connected with any university in the United States. HP's years of research and development into programmable calculators has combined with this storehouse of applied knowledge of data analysis to develop these first three volumes of statistical programs on the 9815.



FIRST THREE VOLUMES AVAILABLE

- Statistics, Volume 1 — General Statistics
- Statistics, Volume 2 — Analysis of Variance and Regression Analysis
- Statistics, Volume 3 — Nonparametric Statistics

Each volume is ready to use and includes:

- Prerecorded cartridge containing all of the programs in that volume.
- Overlay template that labels the 15 user defined keys.
- Operating manual describing each program along with meaningful examples.

All three volumes take advantage of the 9815's AUTO START feature. This saves you time in getting started. You simply place the overlay template on the 9815's user definable keys, insert the cartridge, and turn it on. The 9815 automatically loads the first program file into memory and executes the program. The 15 user definable keys are then defined and you are ready to go to work. All three volumes may be ordered on combined Part Number 09815-15030. Volume 1 uses the basic 9815. Volumes 2 and 3 require option 2.

Statistics on the HP 9815

HEWLETT  PACKARD

STATISTICS, VOLUME 1 GENERAL STATISTICS

The first volume of programs provides many of the simple statistical routines that you use over and over again. All of the programs will operate in a standard 476-program-step machine. Here is a listing of the programs included in Volume 1 (Part Number 09815-15000):

- **Basic Statistics for One Variable** — Includes arithmetic mean, variance, standard deviation, standard error of the mean, second, third and fourth moments about the mean, geometric mean, harmonic mean and the range, along with correction features for grouped and ungrouped data.
- **Basic Statistics for Two to Five Variables** — Computes means and variances for between two and five variables, as well as computing the variance/covariance and correlation matrices.
- **Permutations and Combinations.**
- **Random Number Generator.**
- **Normal Distribution** — Generates probabilities if given an ordinate value or generates tabled values if given a probability.
- **Chi-Square Distribution** — Generates right-tail probabilities given a value and the degrees of freedom.
- **t-Distribution** — Generates right-tail probabilities given a value and the degrees of freedom.
- **Family Regression** — Generates a family of curves and the associated coefficients for the following seven models:

$$y = a + bx$$

$$y = a + bx + cx^2$$

$$y = ax^b$$

$$y = ae^{bx}$$

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

$$y = a + b(1/x)$$

$$1/y = a + bx$$

Included with each model is a complete analysis of variance table and correlation coefficient.

- **Paired t-Statistic** — Calculates Student's t for paired data sets.
- **t-Statistic for Two Means** — Tests the hypothesis that there is a difference between two population means by the t-statistics.
- **Chi-Square Evaluation** — Calculates a χ^2 value for data which has either equal or unequal expected values.
- **2xk Contingency Table** — Calculates the chi-square value and Pearson's coefficient of contingency to test for independence between two data sets.
- **Histogram** — Calculates and prints on the printer a histogram of up to 20 cells, as well as all the cell statistics.

AUTO START

```

STATISTICS
VOLUME 1
PART NO.:
09815-15000
REV. A
=====
SELECT PROGRAM.
=====
DATA?
1=UNGROUPED
2=GROUPED
1.00*

ENTER X(I)
12.30
25.60
14.20
15.60
18.20
17.10
12.00
8.90

ADD OR DELETE?

SUM X(I)= 123.90
N= 8.00

ARITH. MEAN=
15.49

VARIANCE= 25.66
STD. DEV.= 5.07
STD. ERROR= 1.79

M2= 22.45
M3= 86.94
M4= 1581.95

```

SKWENESS= 0.82
KURTOSIS= 3.14

GEOM. MEAN=14.81
HARM. MEAN=14.18

MIN= 8.90
MAX= 25.60
RANGE= 16.70

ADD OR DELETE?
KEY NOT DEFINED
WHICH ONE?
1=NORMAL
2=CHI-SQUARE
3=T

3.00*

ENTER X 0.84*

ENTER V 37.00*

P(X)= 0.20

=====

SELECT PROGRAM.

=====

ENTER # OF CELLS (20 MAX) 10.00*

ENTER CELL WIDTH 1.00*

ENTER OFFSET 0.00*

ENTER X(I) 1.00

4.00

9.00

4.00

ADD OR DELETE?

+
+X
+XX
+XXX
+XXXXX
+XXXXXXXX
+XXXXXXXX
+XXX
+XXX
+X
EACH X=3%

MEAN= 5.04
S.D.= 1.91
N= 51.00

MIN= 1.00
MAX= 9.00
RANGE= 8.00

CELL
STATISTICS

CELL # 1.00
LOWER BOUND=

0.00
OBS. IN CELL=

0.00
% REL. FREQ.=

0.00

CELL # 2.00
LOWER BOUND=

1.00
OBS. IN CELL=

2.00
% REL. FREQ.=

3.92

Samples of General Statistics Programs

STATISTICS, VOLUME 2 ANALYSIS OF VARIANCE AND REGRESSION ANALYSIS

This collection of programs provides you with the most widely used classical statistical analysis techniques available today. The tremendous power and flexibility of the HP 9815 is amply demonstrated by these programs. Who would believe that something only as big as yesterday's adding machine could be calculating the coefficients for an eleven-variable multiple regression or analyzing a three-way analysis of variance, and providing complete tables of means and permitting contrast calculations? Whether it is a tough regression or model building problem of production yields or an attempt to find that new and better process with analysis of variance, your data won't be confined to those black, three-ring binders any longer with the HP 9815 and Volume 2 of the statistics library.

These programs operate as conveniently as those in the rest of the statistical library. Simply insert the prerecorded cartridge into the 9815, place the overlay template on the 15 user defined keys and turn the machine on. You are ready to go. Press one of the user defined keys to select your program and just start entering the data. If you make a mistake with the data, don't worry. All the programs allow you to correct, add, or delete any of your points and continue the analysis.

All of the programs in this second volume may optionally be used with the 132-column HP 9871A Printer. See examples 1 and 2.

Here are the programs in Volume 2 (Part Number 09815-15010):

- **One-Way Analysis of Variance** — Performs a one-way AOV for balanced or unbalanced design providing cell means, complete AOV table, comparisons between treatments, and Bartlett's test.
- **Two-Way Analysis of Variance** — Performs a complete two-way AOV for a balanced design, calculating and printing cell means and variances, row and column means, and overall means. A complete AOV table is printed, as well as allowing row or column contrasts.
- **Three-Way Analysis of Variance** — Performs a complete three-way AOV. Also, main effect, two-way, and overall means are printed; and comparisons can be made between the means of any factor.
- **Latin Square Analysis** — Calculates and prints a complete latin square AOV as well as row, column treatment, and overall means.
- **Analysis of Covariance** — Calculates a complete analysis of covariance table for equal numbers of observations per treatment. The number of observation must be less than 40.
- **Multiple Comparison Procedures** — This program is a great help for those using any AOV procedures because it graphically portrays where the differences between the means lie, either on the HP 9862 Plotter or the HP 9871 Printer. See example 2.

ONE WAY AOV

NUMBER OF TRTS		3				
TRT #	OBS.					
1	10.0000	8.0000	5.0000	12.0000	14.0000	11.0000
2	6.0000	9.0000	8.0000	13.0000		
3	14.0000	13.0000	10.0000	17.0000	16.0000	

CELL STATS		N	MEAN	VAR.	STD.DEV.
	6	10.0000	10.0000	3.1623	
	4	9.0000	8.6667	2.9439	
	5	14.0000	7.5000	2.7386	

AOV TABLE

SOURCE	DF	SS	MS	F
TOTAL	14	172.9333		
TRT.	2	66.9333	33.4667	3.7887
ERROR	12	106.0000	8.8333	
DF NUM	2			
DF DENOM	12			

TRT. CONTRASTS FOR 3 TRTS.

0.6667	-1.0000	0.0000
--------	---------	--------

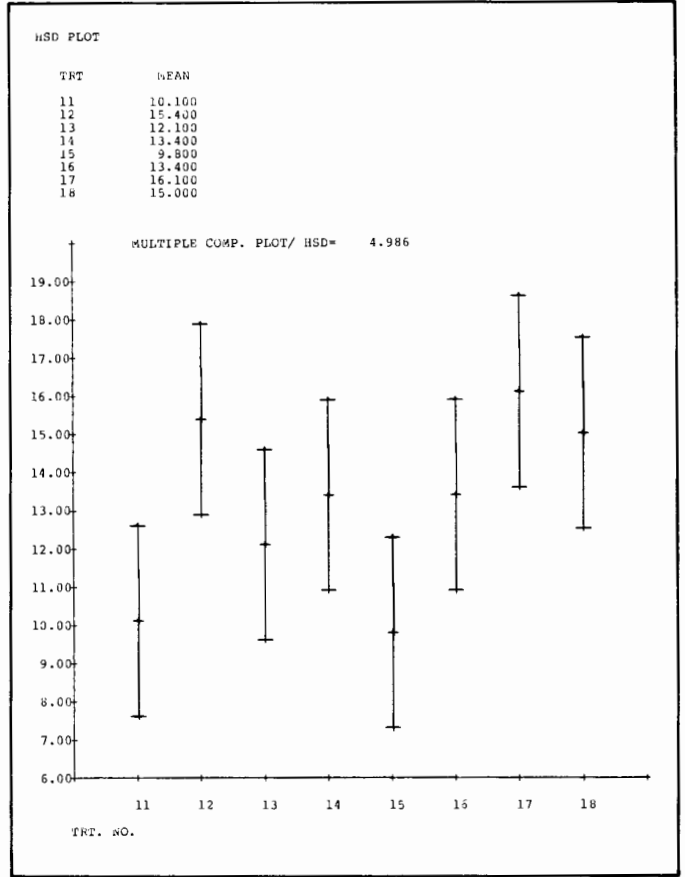
F RATIO	0.2717	DF NUM	1	DF DENOM	3
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CHI-SQUARE = 0.0819 WITH 1 AND 2 DEGREES OF FREEDOM

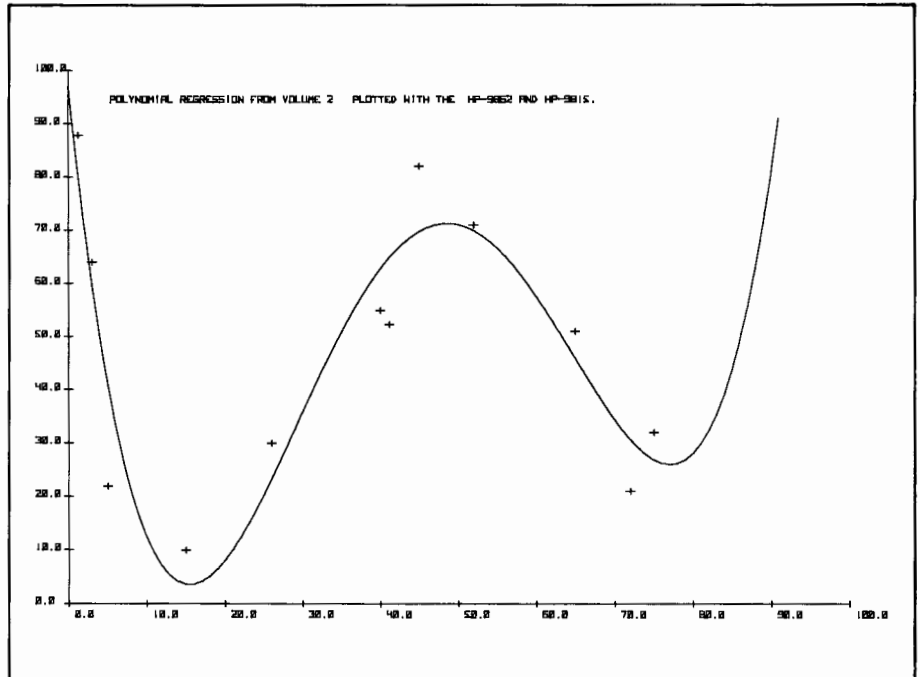
**9871 Output of One-Way AOV, Vol. 2
Example 1**

- **Multiple Linear Regression** — Fits an equation of the form $y = b_0 + b_1x_1 + \dots + b_kx_k$ to data sets of the form $y, x_1, \dots, x_k, k \leq 11$. Data entry can be from keyboard or from previously stored data cartridge files. Any incorrect data may be edited and a data set may be added or deleted. The output includes means and variances for each variable, the correlation matrix, a complete analysis of variance table, and the regression coefficients. If data is stored on data cartridge, residuals can be calculated and \hat{y} evaluation can be done.
- **Polynomial Regression** — Fits an p th degree polynomial to data of the form (X_i, Y_i) where $p \leq 9$. The model is $y = b_0 + b_1x + b_2x^2 + \dots + b_px^p$.

- Data entry can be from keyboard or from previously stored data cartridge files. Any incorrect data may be edited and a data set may be added or deleted. The output includes means and variances of x and y , a simple correlation coefficient, a complete analysis of variance table, and the regression coefficients. If data is stored on cassette, residuals can be calculated and \hat{y} evaluation can be done, example 3.
- **F- and t-Distributions** — To improve the convenience of this volume, the F- and t-distributions have been included and eliminate the need to look up tables. This program calculates probabilities for F- and t-distributions. For an F probability, given a numerator degrees of freedom, a denominator degrees of freedom, and an F value, this program calculates the probability that an F random variable has a value greater than or equal to the input value. For a t probability, given a t value with n degrees of freedom, this program calculates the probability that a t random variable is greater than or equal to the input value.



**9871 Output of Multiple Comparison Procedure, Vol. 2
Example 2**



**Plot of Computed Polynomial Equation and Data, Vol. 2
Example 3**

STATISTICS, VOLUME 3 NONPARAMETRICS

The third volume of statistical programs available for the 9815 (Part Number 09815-15020) concentrates on nonparametrics or distribution-free statistics. Typically, the statistical procedures which are most often used assume that the data comes from a normal distribution. Often, this assumption is not valid and the tests available in this third volume are necessary for any form of statistical inference.

Three Types of Data

• One Sample

Data that is gathered under one set of experimental conditions is considered as one sample or a single vector of observations. They usually represent a sample or set of measurements on a larger population in an attempt to determine properties of that larger population, rather than having to measure every value. Some of the reasons for one sample analysis are to obtain the basic statistics that represent the data, i.e., mean, standard deviation, largest value, smallest value, etc., and to check for outliers or "mavericks" in the data. These are all basic techniques that permit a characterization or a description of the population, rather than present every point in the population (a complete, but rather dry description). All of these descriptive statistics are presented in the one sample ranking program in Volume 3.

• Independent Sample

When data is gathered in a manner such that the observations in the first sample are not related to the observations in the second sample, we say that we have two independent samples.

The nonparametric tests available in Volume 3 can be used to determine if the population responses for the first sample are significantly different from the second sample based on these samples. The two tests available for two independent samples and the general hypothesis which can be tested are:

- 1. Median Test** — Both populations have the same median. The test procedure assumes that the distributions do not differ except in terms of their median.
- 2. Mann-Whitney Test** — The probability functions are the same, i.e., the population distributions have the same shape. The probability that a control observation is greater than an experimental value is $\frac{1}{2}$. Quite frequently this test is used to determine if the "average" values are the same between two populations.

• Two Paired Samples

For the situation in which the observations in the first sample are paired or related to the observation in the second sample, we will, of course, have exactly the same number of observations in each sample. Four keys have been defined for this situation, in addition to the data entry key.

AUTO START NONPARAMETRIC ANALYSIS

PART NO. :
09815-15020
REV. A
ONE SAMPLE
ANALYSIS
ENTER DATA
1.0000
2.0000
5.0000
4.2000

ONE SAMPLE RANKING AND STAT

1.0000
1.6000
2.0000
2.3000
N 15
MEAN 4.6667
MEDIAN 5.0000
MIDRANGE 5.0000
VARIANCE 5.9538
STD. DEV. 2.4400
RANGE 8.0000

PAIRED DATA ANALYSIS

ENTER X, THEN Y.
12.0000
15.0000
11.0000
18.0000
13.0000
16.0000
19.0000
14.0000

PAIRED DATA SIGN TEST

NO. OF POSITIVE
DIFFERENCES 3
NUMBER OF TIES
(DELETED FROM
TEST) 0
YIELDS A STD.
NOR. DEV. OF
0.0000

SELECT KEY

WILCOXON SIGNED RANK TEST

SUM OF RANKS OF
POS. DIFFERENCES
11.0

NUMBER OF DIFF.
EQUAL TO ZERO 0

STD. NOR. DEV.
0.1048

SELECT KEY

SPEARMAN'S RANK CORRELATION

RHO -0.0286

SELECT KEY

KENDALL'S TAU

NUMBER OF
CONCORDANT PAIRS
7

NUMBER OF
DISCORDANT PAIRS
8

TAU -0.0667

SELECT KEY

INDEPENDENT SAMPLES

DATA ENTRY

ENTER X'S

12.0000
13.0000
15.6000
14.0000
21.0000
18.0000
26.0000
11.0000
8.0000
14.0000
5.0000

CORRECTIONS?

N 11
MEAN 14.3273
MEDIAN 14.0000
MIDRANGE 15.5000
VARIANCE 34.1382
STD. DEV. 5.8428
RANGE 21.0000

SELECT KEY

MANN-WHITNEY TEST

SUM OF X RANKS
130.5
STD. NOR. DEVIATE
1.6927

SELECT KEY

MEDIAN TEST

GRAND MEDIAN

12.6500
NO. OF X'S <=
GRAND MEDIAN
4

CHI SQUARE VALUE
2.7732

SELECT KEY

Samples of Nonparametric Programs

The relationship between two treatments (or groups) of paired observations may be studied by looking at the correlation between the pair. In order to calculate the correlation between the X's and the Y's, two measures of correlation on the ranks of the original data are available. Spearman's Rho determines the ranks for the X's and the ranks for the Y's and then calculates the ordinary correlation coefficient on the ranks. The Kendall's Tau rank correlation is slightly more complicated.

Two other tests are available to determine if the X group (treatment one) is significantly different from the Y group (treatment two). Both tests eliminate the effects of the pairing of the observations in order to measure true group difference. These tests and their hypotheses are:

1. The Sign Test — Prob. $X > Y = P$ $[X < Y] = \frac{1}{2}$

This test really is a binomial test equivalent to determining if a coin is balanced (one half, heads; one half, tails).

2. Wilcoxon Signed Rank Test — The values of X tend to be about the same as the values of Y. The average values are about the same. This test is equivalent to the paired t-test.

ORDERING INFORMATION

Any or all of the 9815 statistics software volumes can be ordered through your local HP sales office. Ask for the following Part Numbers:

9815 Statistics, Volume 1 —
09815-15000
9815 Statistics, Volume 2 —
09815-15010
9815 Statistics, Volume 3 —
09815-15020

Volume 1 requires the basic machine. Option 2 is required with Volumes 2 & 3.



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