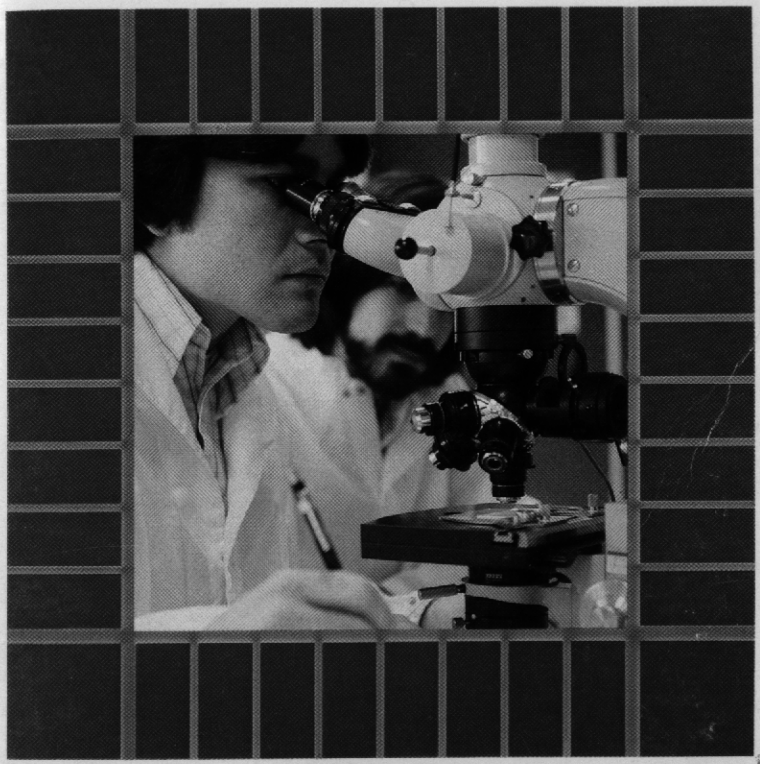
HEWLETT-PACKARD

HP-32E

OWNER'S HANDBOOK



"The success and prosperity of our company will be assured only if we offer our customers superior products that fill real needs and provide lasting value, and that are supported by a wide variety of useful services, both before and after sale."

Statement of Corporate Objectives.
Hewlett-Packard

When Messrs. Hewlett and Packard founded our company in 1939, we offered one superior product, an audio oscillator. Today, we offer over 3500 quality products, designed and built for some of the world's most discerning customers.

Since we introduced our first scientific calculator in 1967, we've sold millions worldwide, both pocket and desktop models. Their owners include Nobel laureates, astronauts, mountain climbers, businesspersons, doctors, students, and homemakers.

Each of our calculators is precision crafted and designed to solve the problems its owner can expect to encounter throughout a working lifetime.

HP calculators fill real needs. And they provide lasting value.

HEWLETT PACKARD

HP-32E
Advanced Scientific Calculator
Owner's Handbook

July 1978

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Contents

Your HP-32E

Congratulations!

Your HP-32E is another professional-quality personal calculating product from the Hewlett-Packard line of calculators—calculators whose durability, size, and ease of operation have made them the choice for use by climbers on Mt. Everest and astronauts in outer space. Doctors, engineers, scientists, and other people who require instant answers to complex and highly technical problems use Hewlett-Packard calculators. You're in good company with HP!

This handbook has been designed to be used in conjunction with *Solving Problems With Your Hewlett-Packard Calculator*. These two books will help you get the most from your HP-32E. In their pages you'll find a reference guide to every basic operation your calculator can perform.

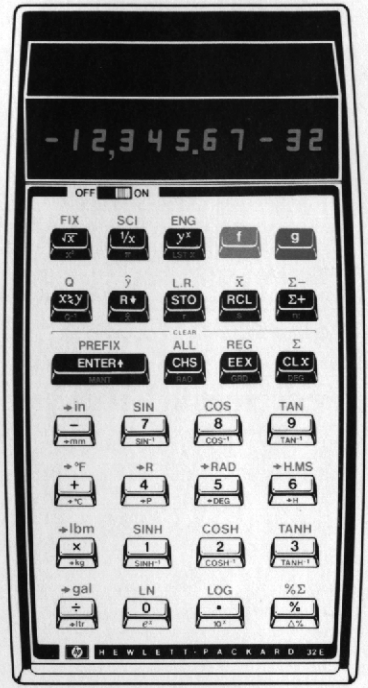
If you are new to HP calculators and their RPN logic system, you will want to study *Solving Problems With Your Hewlett-Packard Calculator* before continuing with this handbook. Even if you already own another HP calculator, glance through the solving problems book. You may find some new features you're not familiar with.

Get to know your HP-32E. It's easy.

HP-32E
Advanced Scientific Calculator

Fold Out

The HP-32E
Advanced Scientific Calculator



Automatic Memory Stack

T

Z

Y

Displayed X

LAST X

Storage Registers

R_0 R_1 R_2 R_3 R_4 R_5 R_6 R_7 R_8

$R_{.0}$ n

$R_{.1}$ Σx

$R_{.2}$ Σx^2

$R_{.3}$ Σy

$R_{.4}$ Σy^2

$R_{.5}$ Σxy

Function Index

OFF ON
Power switch.

[f] Pressed before function key, selects gold function printed above key.

[g] Pressed before function key, selects blue function printed on lower face of key.

CLEAR [PREFIX]
Cancels the following keystrokes or sequences of keystrokes when pressed after them: [f], [g], [STO], [RCL], [STO] [•], [RCL] [•], [STO] [+], [STO] [−], [STO] [×], [STO] [÷], [STO] [+] [•], [STO] [−] [•], [STO] [×] [•], [STO] [÷] [•], [FIX], [SCI], [ENG].

Digit Entry

[0] through [9] Digit keys.

[•] Decimal point.

[ENTER↑] Enters a copy of number displayed in X-register into Y-register. Used to separate numbers.

[CHS] Changes sign of mantissa or exponent in displayed X-register.

[EEX] Enter exponent. Digits keyed in immediately following this key comprise the exponent.

Display Control

[FIX] Fixed point display. Followed by a digit key, specifies fixed point notation display.

[SCI] Scientific display. Followed by a digit key, specifies scientific notation display.

[ENG] Engineering display. Followed by a digit key, specifies engineering notation display.

[MANT] Mantissa. Temporarily displays all 10 digits of the mantissa of the number in the X-register.

Number Manipulation

[x≷y] Exchanges contents of X- and Y-registers.

[R↓] Rolls down contents of stack for viewing in displayed X-register.

[CLx] Clears contents of displayed X-register.

CLEAR [ALL] Clears contents of stack registers (X, Y, Z, and T), LAST X register, and all storage registers (R_0 through R_8, and $R_{.0}$ through $R_{.5}$).

Storage

[STO] Store. Followed by a digit key 0 through 8 or by a decimal point and a digit key 0 through 5, stores displayed number in specified storage register. Also used to perform storage register arithmetic.

[RCL] Recall. Followed by a digit key 0 through 8 or by a decimal point and a digit key 0 through 5, recalls value from specified storage register into the displayed X-register.

CLEAR [REG] Clears contents of storage registers R_0 through R_8.

[LST x] Recalls number displayed before previous operation back into displayed X-register.

Statistical

[Q] Computes area under the standard normal distribution curve to the left of x.

[Q⁻¹] Computes x, given the area under the standard normal distribution curve to the left of x.

[ŷ] Linear estimate. Computes estimated value of y for a given value of x.

[x̂] Linear estimate. Computes estimated value of x for a given value of y.

[L.R.] Linear regression. Computes y-intercept and slope for linear function approximated by x and y values accumulated using [Σ+]. The value of the y-intercept is placed in the X-register; the value of the slope is placed in the Y-register.

[r] Correlation coefficient. Computes "goodness of fit" between the x and y values accumulated using [Σ+] and the linear function which they approximate.

[x̄] Computes means (averages) of x and y values accumulated using [Σ+].

[s] Computes standard deviations of x and y values accumulated using [Σ+].

[Σ+] Accumulates statistical data in storage registers R_0 through R_5 using numbers in X- and Y-registers.

[Σ−] Subtracts from statistical data in storage registers R_0 through R_5 using numbers in X- and Y-registers.

CLEAR [Σ] Clears statistical storage registers (R_0 through R_5).

Mathematical

[√x] Computes square root of number in displayed X-register.

[x²] Computes square of number in displayed X-register.

[1/x] Computes reciprocal of number in displayed X-register.

[π] Places value of pi (3.141592654) into X-register.

[n!] Factorial. Computes $n \cdot (n-1) \ldots 3 \cdot 2 \cdot 1$, where n is number in X-register.

[+], [−], [×], [÷] Arithmetic operations.

Trigonometric

[SIN] [COS] [TAN] Computes sine, cosine, or tangent of number in displayed X-register.

[SIN⁻¹] [COS⁻¹] [TAN⁻¹] Computes arc sine, arc cosine, or arc tangent of number in displayed X-register.

[RAD] Sets radians mode for argument of trigonometric functions.

[GRD] Sets grads mode for argument of trigonometric functions.

[DEG] Sets decimal degrees mode for argument of trigonometric functions.

[→RAD] Converts decimal degrees to radians.

[→DEG] Converts radians to decimal degrees.

[→H.MS] Converts decimal hours or degrees to hours, minutes, seconds or degrees, minutes, seconds.

[→H] Converts hours minutes, seconds or degrees, minutes, seconds to decimal hours or degrees.

Hyperbolic

[SINH] [COSH] [TANH] Computes hyperbolic sine, hyperbolic cosine, or hyperbolic tangent of number in displayed X-register.

[SINH^{-1}] [COSH^{-1}] [TANH^{-1}] Computes inverse hyperbolic sine, inverse hyperbolic cosine, or inverse hyperbolic tangent of number in displayed X-register.

Logarithmic and Exponential

[y^x] Raises number in Y-register to power of number in displayed X-register.

[LN] Computes natural logarithm (base e, 2.718281828) of number in displayed X-register.

[e^x] Natural antilogarithm. Raises e (2.718281828) to power of number in displayed X-register.

[LOG] Computes common logarithm (base 10) of number in displayed X-register.

[10^x] Common antilogarithm. Raises 10 to power of number in displayed X-register.

Polar/Rectangular Conversion

[→P] Converts rectangular (x,y) coordinates in X- and Y-registers to polar (r,θ) coordinates.

[→R] Converts polar (r,θ) coordinates in X- and Y-registers to rectangular (x,y) coordinates.

Metric Conversion

[→in] Converts millimeters to inches.

[→mm] Converts inches to millimeters.

[→°F] Converts degrees Celsius to degrees Fahrenheit.

[→°C] Converts degrees Fahrenheit to degrees Celsius.

[→lbm] Converts kilograms to pounds (mass).

[→kg] Converts pounds (mass) to kilograms.

[→gal] Converts liters to gallons (U.S.).

[→ltr] Converts gallons (U.S.) to liters.

Percentage

[%] Computes x percent of y.

[Δ%] Computes percent difference between number in Y-register and number in X-register.

[%Σ] Computes percent that x is of the number (Σx) in storage register R$_{.1}$.

Specific Features of the HP-32E

Most of the features found on your HP-32E are discussed in *Solving Problems With Your Hewlett-Packard Calculator*. However, several features that are unique to the HP-32E or new to HP calculators are discussed in this section.

Self-Check

Your HP-32E is loaded with features that make it easy to use and give you confidence that the answers you calculate are right, every time. The self-check capability, a feature found on many sophisticated electronic instruments and computers, was designed for just those reasons. We don't expect you to ever have a problem with your calculator, but if you think that it isn't operating properly, press [STO] [ENTER↑]. This tells the calculator to check for faults in its electronic components.

If no problems are found, *-8,8,8,8,8,8,8,8,8,8,* will appear in the display. To clear the display, press any key.

If your calculator is not working properly, the display will either go blank, show something other than the display shown above, or show *Error 9*. If you get any of these results from the self-check, return your calculator to Hewlett-Packard for service. (Refer to Shipping Instructions in appendix A.)

> **Note:** Doing the self-check clears the stack registers (X, Y, Z, and T), LAST X register, and all storage registers (R_0 through R_8, and $R_{.0}$ through $R_{.5}$).

Mantissa Display

Your HP-32E stores numbers and calculates with a full 10-digit mantissa, even when the display shows a shorter mantissa. If you wish to see all 10 digits of the mantissa, press [9] [MANT] and hold down the [MANT] key. While you hold the key down, the display shows all 10 digits. After you release the key, the display will again show its former contents.

Storage Registers

To supplement the power provided by the four-register automatic memory stack and the LAST X register, your HP-32E contains 15 additional storage registers: R_0 through R_8, and $R._0$ through $R._5$. *Solving Problems With Your Hewlett-Packard Calculator* describes how to use registers R_0 through R_8 for storing and recalling numbers and for storage register arithmetic. You can do these operations with registers $R._0$ through $R._5$ by pressing the decimal point key before the number of the register (0 through 5). Registers $R._0$ through $R._5$ are also used for accumulation of statistical data by the statistical functions.

Statistical Functions

Accumulations

Pressing the [Σ+] key computes certain important sums and products of the values in the X- and Y-registers. The results are automatically accumulated in storage registers $R._0$ through $R._5$. Before you start to calculate accumulations with a new set of x *and* y values, you should first clear these registers by pressing [f] CLEAR [Σ]. Then, do the following for each pair of x and y values in your data:

1. Key the y value into the X-register.
2. Press [ENTER↑] to raise the y value into the Y-register.
3. Key the x value into the X-register.
4. Press [Σ+].

If your statistics problem involves only one variable (x) instead of two (x and y), the procedure is similar. First clear the statistical storage registers $R._0$ through $R._5$. In addition, if the contents of the Y-register are not zero, you should clear the Y-register also. (A nonzero number in the Y-register during *one*-variable calculations of s, r, L.R. $\hat{x}$, or $\hat{y}$ may result in a display of ***Error 3***.) Pressing [f] CLEAR [ALL] will clear registers $R._0$ through $R._5$ and the Y-register, but will also clear registers R_0 through R_8. Therefore, if there are numbers stored in registers R_0 through R_8 that you want to save, you should press the keys [f] CLEAR [Σ] [CLx] [ENTER↑] instead of [f] CLEAR [ALL]. After clearing the registers, do the following for each value of x in your data:

1. Key the number into the X-register.
2. Press [Σ+].

Each time you press [Σ+], the following operations are performed:

1. The number in the X-register is added to the contents of storage register $R_{.1}$.
2. The square of the number in the X-register is added to the contents of storage register $R_{.2}$.
3. The number in the Y-register is added to the contents of storage register $R_{.3}$.
4. The square of the number in the Y-register is added to the contents of storage register $R_{.4}$.
5. The number in the Y-register is multiplied by the number in the X-register, and the product is added to the contents of storage register $R_{.5}$.
6. The number 1 is added to the contents of storage register $R_{.0}$. The result—the number of (x,y) data pairs accumulated so far—is copied into the displayed X-register.

After you press [Σ+], the number previously in the X-register appears in the LAST X register. The number previously in the Y-register is not changed.

To summarize, this is where the statistical accumulations are stored inside your calculator:

Register	Contents
$R_{.0}$	n: number of data pairs accumulated.
$R_{.1}$	Σx: summation of x values.
$R_{.2}$	Σx^2: summation of squares of x values.
$R_{.3}$	Σy: summation of y values.
$R_{.4}$	Σy^2: summation of squares of y values.
$R_{.5}$	Σxy: summation of products of x values and y values.

Some sets of data consist of x or y values that all differ from some number by a comparatively small amount. You can maximize the precision of any statistical calculation involving such data by entering into the calculator only the differences between each value and a number approximating the average of the values. When you do this, this number must be added to the result of calculating $\bar{x}$, $\bar{y}$, $\hat{x}$, $\hat{y}$, or the y-intercept of L.R. For example, if your x values consist of 665999, 666000, and 666001, you should enter the data as −1, 0, and 1. If afterwards you calculate $\bar{x}$ or $\hat{x}$, add 666000 to the answer. In some cases the calculator cannot compute s, r, L.R., $\hat{x}$, or $\hat{y}$ with data values that are too close to each other, and if you attempt to do so the calculator will display ***Error 3***. This will not happen, however, if you normalize the data as described above.

> **Note:** Unlike storage register arithmetic, the [Σ+] operation allows overflows (i.e., numbers whose magnitudes are greater than $9.999999999 \times 10^{99}$) in storage registers $R_{.0}$ through $R_{.5}$ without indicating ***Error 1*** in the display.

To use any of the accumulations, you can recall the contents of the desired storage register into the displayed X-register by pressing [RCL] [•] followed by the number of the register. If this is done immediately after pressing [Σ+] (or [Σ−]), the accumulation recalled is written over the number of data pair entries (n) in the display.

If you want to use both Σx and Σy, press [RCL] [Σ+]. This simultaneously copies Σx from $R_{.1}$ into the displayed X-register and copies Σy from $R_{.3}$ into the Y-register. If this is done immediately after pressing [Σ+], [Σ−], [CLx], or [ENTER↑], the number in the Y-register is first lifted into the Z-register. Otherwise, the numbers in the X- and Y-registers are first lifted into the Z- and T-registers, respectively.

Example: Find Σx, Σx^2, Σy, Σy^2, and Σxy for the paired values of x and y listed below.

y	7	5	9
x	5	3	8

Keystrokes	Display	
f CLEAR Σ	*0.0000*	Clear statistical storage registers. (Display shown assumes no results remain from previous calculations.)
7 ENTER↑	*7.0000*	
5 Σ+	*1.0000*	First pair is accumulated; n = 1.
5 ENTER↑	*5.0000*	
3 Σ+	*2.0000*	Second pair is accumulated; n = 2.
9 ENTER↑	*9.0000*	
8 Σ+	*3.0000*	Third pair is accumulated; n = 3.
RCL . 1	*16.0000*	Sum of x values from register $R_{.1}$.
RCL . 2	*98.0000*	Sum of squares of x values from register $R_{.2}$.
RCL . 3	*21.0000*	Sum of y values from register $R_{.3}$.
RCL . 4	*155.0000*	Sum of squares of y values from register $R_{.4}$.
RCL . 5	*122.0000*	Sum of products of x and y values from register $R_{.5}$.
RCL . 0	*3.0000*	Number of entries (n = 3) from register $R_{.0}$.

Deleting and Correcting Data

If you key in an incorrect value and have not yet pressed Σ+, press CLx and key in the correct value.

If you want to change one of the values, or if you discover after pressing Σ+ that one of the values was erroneous, you can correct the accumulations by using the Σ− *(summation minus)* key as follows:

1. Key the *incorrect* data pair into the X- and Y-registers. (You can use LSTx to return a single incorrect data value to the displayed X-register.)

2. Press [f] [Σ−] to delete the incorrect data.
3. Key in the correct values for x and y. If one value of an (x,y) data pair is incorrect, you must delete and reenter both values.
4. Press [Σ+].

For example, if the last data pair (8,9) in the previous example should have been (8,6), you could correct the accumulation as follows:

Keystrokes	Display	
9 [ENTER↑]	*9.0000*	*Incorrect* y value is entered again.
8	*8.*	Correct x value is entered again.
[f] [Σ−]	*2.0000*	Number of entries (n) is now two.
6 [ENTER↑]	*6.0000*	Correct y value is entered.
8	*8.*	X value is entered again.
[Σ+]	*3.0000*	Number of entries is again three.

Mean

Pressing [x̄] computes the arithmetic *mean* (average) of x and y values accumulated in registers $R_{.1}$ and $R_{.3}$, respectively.

When you press [f] [x̄]:

1. The contents of the stack registers are lifted just as they are when you press [RCL] [Σ+], as described on page 10.
2. The mean of the x values ($\bar{x}$) is calculated using the data accumulated in registers $R_{.1}$ (Σx) and $R_{.0}$ (n) according to the formula:

$$\bar{x} = \frac{\Sigma x}{n}$$

   The resultant value for $\bar{x}$ appears in the displayed X-register.
3. The mean of the y values ($\bar{y}$) is calculated using the data accumulated in registers $R_{.3}$ (Σy) and $R_{.0}$ (n) according to the formula:

$$\bar{y} = \frac{\Sigma y}{n}$$

   The resultant value for $\bar{y}$ is available in the Y-register of the stack.

Example: Below is a chart of daily high and low temperatures for a winter week in Fairbanks, Alaska. What are the average high and low temperatures for the week selected?

	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
High	6	11	14	12	5	−2	−9
Low	−22	−17	−15	−9	−24	−29	−35

Keystrokes	Display	
f CLEAR Σ	*0.0000*	Accumulation registers cleared. (Display shown assumes no results remain from previous calculations.)
6 ENTER↑ 22	*22.*	
CHS Σ+	*1.0000*	Number of data pairs (n) is now 1.
11 ENTER↑ 17	*17.*	
CHS Σ+	*2.0000*	Number of data pairs (n) is now 2.
14 ENTER↑ 15	*15.*	
CHS Σ+	*3.0000*	
12 ENTER↑ 9	*9.*	
CHS Σ+	*4.0000*	
5 ENTER↑ 24	*24.*	
CHS Σ+	*5.0000*	
2 CHS ENTER↑	*−2.0000*	
29 CHS Σ+	*6.0000*	

Keystrokes	Display	
9 [CHS] [ENTER↑]	-9.0000	
35 [CHS] [Σ+]	7.0000	Number of data pairs (n) is now 7.
[f] [x̄]	-21.5714	Average low temperature.
[x≷y]	5.2857	Average high temperature.

Standard Deviation

Pressing [s] computes the *standard deviation* (a measure of dispersion around the mean) of the accumulated data. The formulas used by the HP-32E to compute s_x, the standard deviation of the accumulated x values, and s_y, the standard deviation of the accumulated y values, are:

$$s_x = \sqrt{\frac{n\Sigma x^2 - (\Sigma x)^2}{n(n-1)}} \qquad s_y = \sqrt{\frac{n\Sigma y^2 - (\Sigma y)^2}{n(n-1)}}$$

These formulas give the *best estimates* of the *population* standard deviations from the *sample* data. Consequently, the standard deviation given by these formulas is termed by convention the *sample* standard deviation.

When you press [g] [s]:

1. The contents of the stack registers are lifted just as they are when you press [RCL] [Σ+], as described on page 10.

2. The standard deviation of the x values (s_x) is calculated using the data accumulated in registers $R_{.2}$ (Σx^2), $R_{.1}$ (Σx), and $R_{.0}$ (n) according to the formula shown above. The resultant value for s_x appears in the displayed X-register.

3. The standard deviation of the y values (s_y) is calculated using the data accumulated in registers $R_{.4}$ (Σy^2), $R_{.3}$ (Σy), and $R_{.0}$ (n) according to the formula shown above. The resultant value for s_y is available in the Y-register.

Example: Norman Numbercruncher, a rising young math professor at Mammoth University, has developed a new test for measuring the mathematical abilities of college freshmen. To evaluate its effectiveness, he administers the test to the 746 students in Calculus I. Exhausted after grading the tests, Numbercruncher decides to randomly select 8 of the 746 tests and estimate the standard deviation of all the scores from the sample of 8. The scores on the tests selected were 79, 94, 68, 86, 82, 78, 83, and 89. What standard deviation does Numbercruncher calculate?

Keystrokes	Display	
[f] CLEAR [ALL]	*0.0000*	Clear statistical registers and Y-register for new, one-variable problem.
79 [Σ+]	*1.0000*	First score is entered. Notice that since this problem involves only one variable, you don't have to enter a y-value into the Y-register using the [ENTER↑] key.
94 [Σ+]	*2.0000*	Display shows number of scores entered so far.
68 [Σ+]	*3.0000*	
86 [Σ+]	*4.0000*	
82 [Σ+]	*5.0000*	
78 [Σ+]	*6.0000*	
83 [Σ+]	*7.0000*	
89 [Σ+]	*8.0000*	Last score in sample.
[g] [s]	*7.8365*	Standard deviation estimated for the 746 students based on sample of 8.

When your data constitutes not just a sample of a population but rather *all* of the population, the standard deviation of the data is the *true* population standard deviation (denoted σ). The formula for the true population standard deviation differs by a factor of $[(n-1)/n]^{1/2}$ from the formula used for the [s] function. The difference between the values is small, and for most applications can be ignored. Nevertheless, if you want to calculate the exact value of the population standard deviation for an entire population, you can easily do so with just a few keystrokes on your HP-32E. Simply add, using the [Σ+] key, the mean ($\bar{x}$) of the data to the data and then press [g] [s]. The result will be the true population standard deviation of the original data.

Example: Suppose the data from the previous example represented all the final exam scores from Numbercruncher's seminar on transcendental functions. Since this is the first time Numbercruncher has given this seminar, he wants to calculate the standard deviation of the test scores to determine how good his exam was. Numbercruncher takes his calculator in hand, enters the data, then proceeds as follows:

Keystrokes	Display	
[f] [$\bar{x}$]	*82.3750*	Mean of scores.
[Σ+]	*9.0000*	Mean is added to data. Display shows nine total entries.
[g] [s]	*7.3304*	Standard deviation for all scores on final exam.

Linear Regression

Linear regression is a statistical method for finding a straight line that best fits a set of data points, thus providing a relationship between two variables. After a group of data points has been totaled in registers R_0 through R_5, you can calculate the coefficients of the linear equation $y = Ax + B$ using the least squares method by pressing [f] [L.R.]. (Naturally, at least two data points must be in the calculator before a least squares line can be fitted to them.)

To use the linear regression function on your HP-32E, first key in a series of data points using the [Σ+] key. Then press [f] [L.R.].

When you press [f] [L.R.] :

1. The contents of the stack registers are lifted just as they are when you press [RCL] [Σ+], as described on page 10.
2. The slope (A) of the least squares line of the data is calculated using the equation:

$$A = \frac{n\,\Sigma xy - \Sigma x\,\Sigma y}{n\,\Sigma x^2 - (\Sigma x)^2}$$

The slope is available in the Y-register of the stack.

3. The y-intercept (B) of the least squares line of the data is calculated using the equation:

$$B = \frac{\Sigma y\,\Sigma x^2 - \Sigma x\,\Sigma xy}{n\,\Sigma x^2 - (\Sigma x)^2}$$

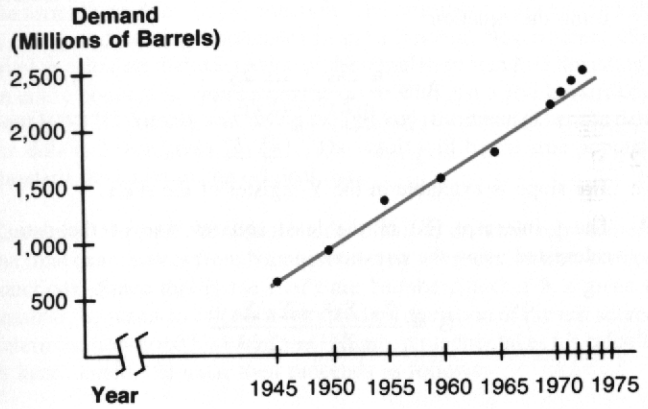
The y-intercept appears in the displayed X-register of the stack.

To use the value for A or to bring it into the displayed X-register, simply shift the stack contents with the [x≷y] key.

Example: Big Lyle Hephaestus, owner-operator of the Hephaestus Oil Company, wishes to know the slope and y-intercept of a least squares line for the consumption of motor fuel in the United States against time since 1945. He knows the data given in the table.

Motor Fuel Demand (Millions of Barrels)	696	994	1,330	1,512	1,750	2,162	2,243	2,382	2,484
Year	1945	1950	1955	1960	1965	1970	1971	1972	1973

Solution: Hephaestus *could* draw a plot of motor fuel demand against time like the one shown below.



However, with his HP-32E, Hephaestus has only to key the data into the calculator using the [Σ+] key, then press [f] [L.R.].

Keystrokes	Display	
[f] CLEAR [Σ]	*0.0000*	Clear statistical storage registers. (Display shown assumes no results remain from previous calculations.)
696 [ENTER↑]	*696.0000*	
1945 [Σ+]	*1.0000*	
994 [ENTER↑]	*994.0000*	
1950 [Σ+]	*2.0000*	
1330 [ENTER↑]	*1,330.0000*	
1955 [Σ+]	*3.0000*	
1512 [ENTER↑]	*1,512.0000*	
1960 [Σ+]	*4.0000*	

Keystrokes	Display	
1750 ENTER↑	*1,750.0000*	
1965 Σ+	*5.0000*	
2162 ENTER↑	*2,162.0000*	
1970 Σ+	*6.0000*	
2243 ENTER↑	*2,243.0000*	
1971 Σ+	*7.0000*	
2382 ENTER↑	*2,382.0000*	
1972 Σ+	*8.0000*	
2484 ENTER↑	*2,484.0000*	
1973 Σ+	*9.0000*	All data pairs have been keyed in.
f L.R.	*-118,290.6295*	The y-intercept of the line.
x≷y	*61.1612*	Slope of the line.

Linear Estimation

With data accumulated in registers R_0 through R_5, a predicted value for y (denoted $\hat{y}$) can be calculated by keying in a new value for x and pressing f $\hat{y}$. Similarly, a predicted value for x (denoted $\hat{x}$) can be calculated by keying in a new value for y and pressing g $\hat{x}$.

For example, with data intact from the previous example in registers R_0 through R_5, if Hephaestus wishes to predict the demand for motor fuel for the years 1980 and 2000, he keys in the new x values and presses f $\hat{y}$. Similarly, to determine the year that the demand for motor fuel is expected to pass 3,500 million barrels, Hephaestus keys in 3,500 (the new value for y) and presses g $\hat{x}$.

Keystrokes	Display	
1980 f $\hat{y}$	*2,808.6264*	Predicted demand in millions of barrels for the year 1980.
2000 f $\hat{y}$	*4,031.8512*	Predicted demand in millions of barrels for the year 2000.
3500 g $\hat{x}$	*1,991.3041*	The demand is expected to pass 3,500 million barrels during 1992.

Correlation Coefficient

Both linear regression and linear estimation presume that the relationship between the x and y data values can be approximated, to some degree, by a linear function (i.e., a straight line). You can use [r] *(correlation coefficient)* to determine how closely your data "fits" a straight line. The correlation coefficient can range from $r = +1$ to $r = -1$. At $r = +1$, the data falls exactly onto a straight line with positive slope, while at $r = -1$, the data falls exactly onto a straight line with negative slope. At $r = 0$, the data cannot be approximated at all by a straight line.

For example, to calculate the correlation coefficient for the example above:

Keystrokes	Display	
[9] [r]	*0.9931*	The data approximates a straight line very closely.

Normal Distribution

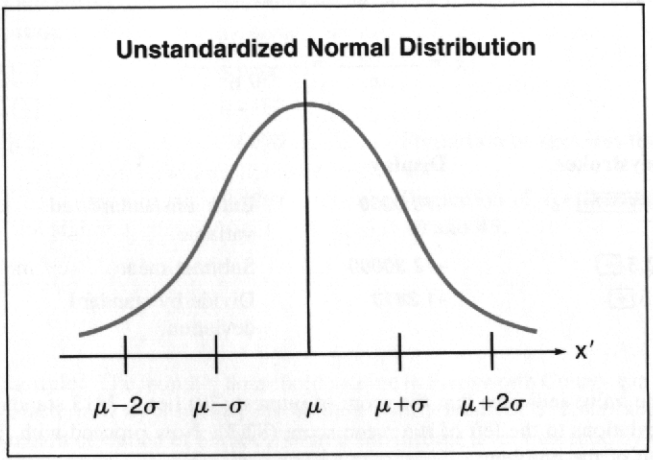
The HP-32E provides two important functions for problems dealing with normal distributions: [Q] and [Q⁻¹]. The function [Q] computes the area under the standard normal distribution curve to the left of x. Its inverse function [Q⁻¹] computes x,* given the area under the standard normal distribution curve to the left of x. The area under the standard normal distribution curve to the left of x is a measure of the probability or frequency of occurrence for all values less than or equal to x.

The number that is input to the function [Q] or returned by the function [Q⁻¹] is the standard variable for the standard normal distribution. Given the mean (μ) and standard deviation (σ) of a normal distribution, the following formulas give the relation between x, the standard variable, and x′, the unstandardized variable of your problem:

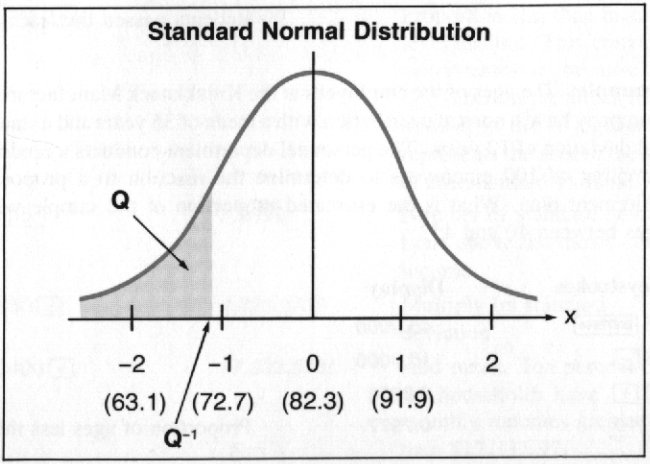
$$x = \frac{x' - \mu}{\sigma} \qquad x' = \sigma x + \mu$$

The standard normal distribution has $\mu = 0$ and $\sigma = 1$.

* The HP-32E computes [Q⁻¹] using a sophisticated iterative algorithm. The computation may take 5 to 15 seconds, during which the display flashes off and on.



Example: The distribution of final exam scores for 200 students has a mean (μ) of 82.3 and a standard deviation (σ) of 9.6. What proportion of the students received passing grades (70 or higher)?



Solution: First, find x using the formula:

$$x = \frac{x' - \mu}{\sigma} = \frac{70 - 82.3}{9.6}$$

Keystrokes	Display	
70 [ENTER↑]	*70.0000*	Enter unstandardized variable.
82.3 [−]	*−12.30000*	Subtract mean.
9.6 [÷]	*−1.2813*	Divide by standard deviation.

The value indicates that the score of interest (70) lies 1.2813 standard deviations to the left of the mean score (82.3). Now proceed with the rest of the problem:

Keystrokes	Display	
[f] [Q]	*0.1001*	Proportion receiving grades *less than* 70.
1 [x≷y] [−]	*0.8999*	About 90 percent of the students passed the test.

Example: The ages of the employees at the Knickknack Manufacturing Company have a normal distribution with a mean of 35 years and a standard deviation of 12 years. The personnel department conducts a random sampling of 100 employees to determine the reaction to a proposed retirement plan. What is the estimated proportion of the sample with ages between 40 and 45?

Keystrokes	Display	
45 [ENTER↑]	*45.0000*	
35 [−]	*10.0000*	
12 [÷]	*0.8333*	
[f] [Q]	*0.7977*	Proportion of ages less than 45.

Keystrokes	Display	
40 ENTER↑	*40.0000*	
35 −	*5.0000*	
12 ÷	*0.4167*	
f Q	*0.6615*	Proportion of ages less than 40.
−	*0.1361*	Proportion of ages between 40 and 45.

Example: The monthly household income in Farnsworth County can be characterized by a normal distribution with a mean of $12,400 and a standard deviation of $3,850. What is the income level exceeded by the highest 10 percent of the households?

Keystrokes	Display	
. 1 ENTER↑	*0.1000*	Highest tenth of households.
1 x≷y −	*0.9000*	Proportion less than income level desired. This conversion is necessary because the Q^{-1} function presumes the number in the X-register represents the area to the *left* of the standard variable.
g Q^{-1}	*1.2816*	Number of standard deviations above the mean income.
3850 ×	*4,933.9735*	Multiply by standard deviation.
12400 +	*17,333.9735*	Add mean. Ten percent of the households have monthly incomes greater than $17,333.97.

Factorial

The [n!] *(factorial)* function computes the product of the integers from 1 to n. This function enables you to quickly and easily solve permutations and combinations.

Example: Willie's Widget Works wants to take photographs of its product line for advertising. How many different ways can the photographer arrange their eight widget models?

Solution: The number of arrangements is given by

$$8! = 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$$

Keystrokes	Display	
8 [g] [n!]	*40,320.0000*	The photographer can arrange the widgets 40,320 different ways.

Example: The photographer looks through his viewfinder and decides that he can show only five widgets if his camera is to capture the intricate details of the widgets on film. How many different sets of five widgets can he select from the eight?

Solution: The number of sets is given by

$$\frac{8!}{(8-5)!\,5!}$$

Keystrokes	Display
8 [g] [n!]	*40,320.0000*
8 [ENTER↑]	*8.0000*
5 [−]	*3.0000*

Keystrokes	Display	
g n!	6.0000	
5 g n!	120.0000	
×	720.0000	
÷	56.0000	The photographer can select 56 different sets of five widgets.

Percent of Sum

The %Σ *(percent of sum)* function permits you to compute the percentage that several values are of a total, while leaving the total intact. It computes the percentage the number in the X-register is of the value in storage register $R_{.1}$. The formula used is:

$$\frac{x}{\Sigma x} \times 100 = \%\ \Sigma$$

The computed value for %Σ writes over the number in the X-register, and the rest of the stack remains unchanged. (x is, of course, preserved in the LAST X register.)

You will probably want to accumulate the total value in register $R_{.1}$ using the Σ+ key before pressing f %Σ . (You could also accumulate a value in register $R_{.1}$ manually, by simply storing the value there using the STO key.)

Example: A compound is made up of 5.4 grams of hydrogen (H), 172.8 grams of oxygen (O) and 866.7 grams of sulfur (S). What is the percentage by weight of each chemical in the compound, and what is the total weight of the compound?

Keystrokes	Display	
f CLEAR ALL	0.0000	Clear all registers.
5.4 STO 1	5.4000	
Σ+	1.0000	
172.8 STO 2	172.8000	
Σ+	2.0000	
866.7 STO 3	866.7000	

Keystrokes	Display	
[Σ+]	*3.0000*	
[RCL] 1 [f] [%Σ]	*0.5168*	Percent of hydrogen in compound.
[RCL] 2 [f] [%Σ]	*16.5375*	Percent of oxygen in compound.
[RCL] 3 [f] [%Σ]	*82.9457*	Percent of sulfur in compound.
[RCL] . 1	*1,044.9000*	Total weight of compound.

Percent Difference

The [Δ%] key gives you the *percent difference*–that is, the relative increase or decrease—between two numbers. To find the percent difference:

1. Key in the base number (typically, the number that occurs first in time).
2. Press [ENTER↑].
3. Key in the second number.
4. Press [g] [Δ%].

The formula used is: $\Delta\% = \frac{100\,(x-y)}{y}$.

A positive result signifies an increase, while a negative result signifies a decrease.

Example: Silas Silversaver's coin collection was appraised in 1974 at $475. An appraisal in 1977 valued the collection at $625. By what percent did the value of the collection increase from 1974 to 1977?

Keystrokes	Display	
475 [ENTER↑]	*475.0000*	
625 [g] [Δ%]	*31.5789*	Percent increase.

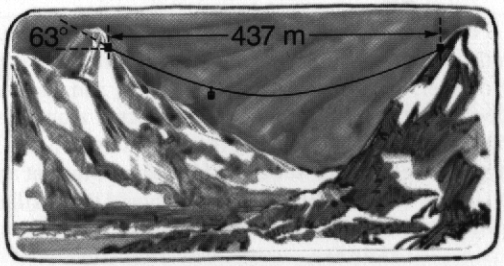
Hyperbolic Functions

The HP-32E provides you with six hyperbolic functions:

- [SINH] Hyperbolic sine.
- [COSH] Hyperbolic cosine.
- [TANH] Hyperbolic tangent.
- [SINH^{-1}] Inverse hyperbolic sine.
- [COSH^{-1}] Inverse hyperbolic cosine.
- [TANH^{-1}] Inverse hyperbolic tangent.

These functions are used just like the trigonometric functions (as described in *Solving Problems With Your Hewlett-Packard Calculator),* with one exception. The hyperbolic functions [SINH], [COSH], and [TANH] always assume their arguments (that is, the number in the display before you press the function key) are measured in radians, and the inverse hyperbolic functions always give an answer measured in radians.

Example: In Upper Lagunia, a tram carries tourists between two peaks in the Baruvian Alps that are the same height and 437 meters apart. How long does it take the tram to travel from one peak to the other if it moves along its cable at 135 meters per minute? Before the tram latches onto the cable, the angle from the horizontal to the cable at its point of attachment is found to be 63°.



Solution: The travel time is given by the following formula:

$$t = \frac{437 \tan 63°}{135 \sinh^{-1}(\tan 63°)}$$

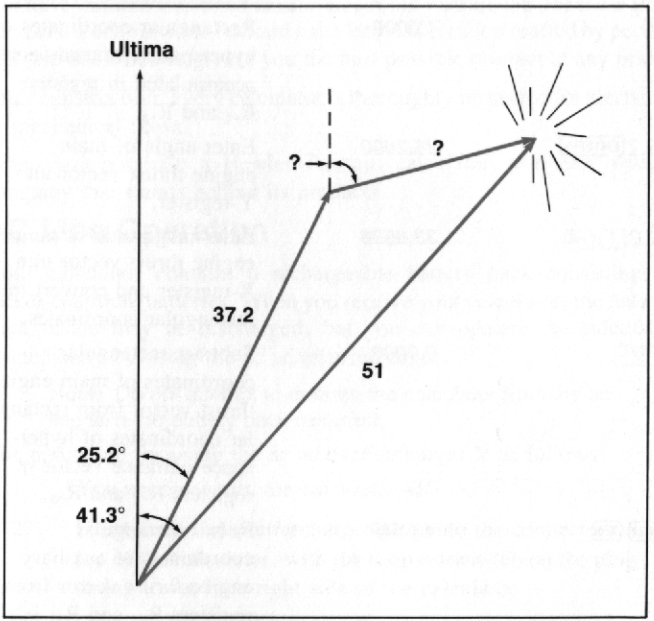
Keystrokes	Display	
g DEG	*0.0000*	Set trigonometric mode to degrees. (Display shown assumes no results remain from previous calculations.)
437 ENTER↑	*437.0000*	
63 f TAN	*1.9626*	
ENTER↑	*1.9626*	
g SINH⁻¹	*1.4268*	
135 ×	*192.6164*	
÷	*0.0102*	
×	*4.4527*	Travel time between peaks is about 4½ minutes.

Vector Arithmetic

You can add or subtract vectors with your HP-32E by using the Σ+ and Σ− keys in conjunction with the →R and →P keys.

Example: Federation starship *Felicity* has emerged victorious from a furious battle with the starship *Thanatos* from the renegade planet Maldek. However, its automatic pilot is kaput, and its main thrust engine is locked on at 37.2 meganewtons directed along an angle of 25.2° from the star Ultima. Consulting the ship's star map, the navigator reports a hyperspace entrance vector of 51 meganewtons at an angle of 41.3° from Ultima. To what thrust and angle should the auxiliary engine be set, for *Felicity* to achieve alignment with the hyperspace entrance vector?

Solution: The required thrust vector of the auxiliary engine is equal to the hyperspace entrance vector minus the thrust vector of the main engine. The vectors are converted to rectangular coordinates using the [→R] key, and their difference is calculated using the [Σ+] and [Σ−] keys. This difference is recalled to the X- and Y-registers using [RCL] [Σ+]. Then, these rectangular coordinates of the auxiliary engine thrust vector are converted to polar coordinates using the [→P] key.



Keystrokes	Display	
[f] CLEAR [Σ]	*0.0000*	Clear statistical registers. (Display shown assumes no results remain from previous calculations.)
[9] [DEG]	*0.0000*	Set trigonometric mode to degrees.

Keystrokes	Display	
41.3 [ENTER↑]	*41.3000*	Enter angle of hyperspace entrance vector into Y-register.
51 [f] [→R]	*38.3145*	Enter magnitude of hyperspace entrance vector into X-register and convert to rectangular coordinates.
[Σ+]	*1.0000*	Rectangular coordinates of hyperspace entrance vector accumulated in registers $R_{.1}$ and $R_{.3}$.
25.2 [ENTER↑]	*25.2000*	Enter angle of main engine thrust vector into Y-register.
37.2 [f] [→R]	*33.6596*	Enter magnitude of main engine thrust vector into X-register and convert to rectangular coordinates.
[f] [Σ−]	*0.0000*	Subtract rectangular coordinates of main engine thrust vector from rectangular coordinates of hyperspace entrance vector in registers $R_{.1}$ and $R_{.3}$.
[RCL] [Σ+]	*4.6549*	Recall rectangular coordinates of auxiliary engine thrust vector from registers $R_{.1}$ and $R_{.3}$ into X-register and Y-register.
[g] [→P]	*18.4190*	Convert to polar coordinates. Display shows required magnitude, in meganewtons, of auxiliary engine thrust vector.
[x≷y]	*75.3613*	Required angle of auxiliary engine thrust vector.

Appendix A

Service and Maintenance

Your Hewlett-Packard Calculator

Your calculator is another example of the award-winning design, superior quality, and attention to detail in engineering and construction that have marked Hewlett-Packard electronic instruments for more than 30 years. Each Hewlett-Packard calculator is precision crafted by people who are dedicated to giving you the best possible product at any price.

After construction, every calculator is thoroughly inspected for electrical or mechanical flaws.

When you purchase a Hewlett-Packard calculator, you deal with a company that stands behind its products.

AC Line Operation

Your calculator contains a rechargeable battery pack consisting of nickel-cadmium batteries. When you receive your calculator, the battery pack inside may be discharged, but you can operate the calculator immediately by using the ac adapter/recharger.

> **Note:** Do not attempt to operate the calculator from the ac line with the battery pack removed.

The procedure for using the ac adapter/recharger is as follows:

1. You need *not* turn the calculator off.
2. Insert the ac adapter/recharger plug into the connector on top of the calculator, with the snap release tab on the plug facing toward the right side of the calculator.
3. Insert the power plug into a live ac power outlet.

   Note: It is normal for the ac adapter/recharger to be warm to the touch when it is plugged into an ac outlet.

> **CAUTION**
>
> The use of a charger other than the HP recharger supplied with the calculator may result in damage to your calculator.

Battery Operation

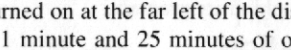
To operate the calculator from battery power alone, simply disconnect the recharger plug from the calculator by grasping the plug between thumb and forefinger, squeezing to depress the snap release tab, and pulling gently. (Even when not connected to the calculator, the ac adapter/recharger may be left plugged into the ac outlet.)

Using the calculator on battery power gives the calculator full portability, allowing you to carry it nearly anywhere. A fully charged battery pack typically provides 3 hours of continuous operation. By turning the power off when the calculator is not in use, the charge on the battery pack should easily last throughout a normal working day.

Low Power

When you are operating from battery power and the batteries get low, a raised decimal is turned on at the far left of the display to warn you that you have between 1 minute and 25 minutes of operating time left.

If the display contains the low power indication, the minus sign looks like an incomplete divide sign:



To return to full power either connect the ac adapter/recharger to the calculator as described under AC Line Operation, or substitute a fully charged battery pack for the one in the calculator.

Battery Charging

The rechargeable batteries in the battery pack are charged while you operate the calculator from the ac adapter/recharger. Batteries will charge with the calculator on or off, provided the batteries are in place and the recharger is connected. Normal charging times between the fully discharged state and the fully charged state are (depending on ac line voltage):

Calculator off:	5 to 9 hours
Calculator on:	17 hours

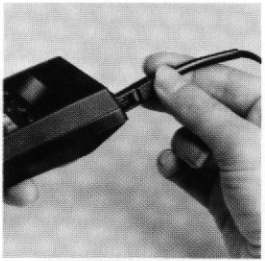
Shorter charging periods will reduce the operating time you can expect from a single battery charge. Whether the calculator is off or on, the calculator battery pack is never in danger of becoming overcharged.

> **Note:** The ac adapter/recharger is a sealed unit and is not repairable. Return it to Hewlett-Packard if service is required.

Battery Pack Replacement

To replace the battery pack use the following procedure:

1. Set calculator ON-OFF switch to OFF and disconnect the ac adapter/recharger from the calculator.



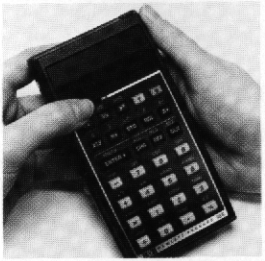
2. Press down on the short ridges of the battery door, close to the edge, until the door release snaps open. Slide the door open.

3. When door is removed, turn calculator over and gently shake, allowing the battery pack to fall into the palm of your hand.

4. Place the new battery pack into the calculator. Your calculator will turn on only if the battery pack is inserted correctly.

5. Insert battery door and slide door back into place.

6. Turn calculator over and turn power on to assure proper battery installation. If the display does not light make sure the battery pack is correctly placed in calculator.



Battery Care

When not being used, the batteries in your calculator have a self-discharge rate of approximately 1 percent of available charge per day. After 30 days, a battery pack might have only 50 to 75 percent of its charge remaining, and the calculator might not even turn on. If a calculator fails to turn on, you should substitute a charged battery pack, if available, for the one in the calculator or plug in the ac adapter/recharger. The discharged battery pack should be charged for at least 12 hours.

If a battery pack will not hold a charge and seems to discharge very quickly in use, it may be defective. If the one-year warranty on the battery pack has not expired, return the defective pack to Hewlett-Packard according to the shipping instructions. (If you are in doubt about the cause of the problem, return the complete calculator along with its battery pack and ac adapter/recharger.) If the battery pack is out of warranty, see your nearest dealer to order a replacement.

WARNING

Do not attempt to incinerate or mutilate the battery pack—the pack may burst or release toxic materials.

Do not connect together or otherwise short-circuit the battery terminals—the pack may melt or cause serious burns.

Temperature Range

Temperature ranges for the calculator are:

Operating	0° to 45°C	32° to 113°F
Charging	15° to 40°C	59° to 104°F
Storage	–40° to 55°C	–40° to 131°F

Service

Blank Display

If the display blanks out, turn the calculator off, then on. If a display of numbers does not appear in the display, check the following:

1. If the ac adapter/recharger is attached to the calculator, make sure it is plugged into an ac outlet.
2. Examine the battery pack to see if the contacts are dirty.
3. Substitute a fully charged battery pack, if available, for the one that was in the calculator.
4. If the display is still blank, try operating the calculator using the ac adapter/recharger (with the batteries in the calculator).
5. If, after step 4, the display is still blank, service is required. (Refer to Limited One-Year Warranty.)

Note: The ac adapter/recharger is a sealed unit and is not repairable. Return it to Hewlett-Packard if service is required.

Repair Policy

Hewlett-Packard calculators are normally repaired and reshipped within five (5) working days of receipt at any repair center. This is an average time and could possibly vary depending upon time of year and work load at the repair center.

Shipping Instructions

The calculator should be returned, along with completed Service Card, in its shipping case (or other protective package) to avoid in-transit damage. Such damage is not covered by warranty and Hewlett-Packard suggests that the customer insure shipments to the repair center. A calculator returned for repair should include the ac adapter/recharger and the battery pack. Send these items to the address shown on the Service Card. *Remember to include a sales slip or other proof of purchase with your unit.*

Whether the unit is under warranty or not, it is your responsibility to pay shipping charges for delivery to the Hewlett-Packard repair center.

After warranty repairs are completed, the repair center returns the unit with postage prepaid. On out-of-warranty repairs, the unit is returned C.O.D. (covering shipping costs and the service charge).

Limited One-Year Warranty

What We Will Do

The HP-32E and its accessories are warranted by Hewlett-Packard against defects in materials and workmanship for one year from date of original purchase. If you sell your calculator or give it as a gift, the warranty is automatically transferred to the new owner and remains in effect for the original one-year period. During the warranty period we will repair or, at our option, replace at no charge a product that proves to be defective provided that you return the product, shipping prepaid, to a Hewlett-Packard repair center.

How to Obtain Repair Service

Hewlett-Packard maintains repair centers in most major countries throughout the world. You may have your calculator repaired at a Hewlett-Packard repair center anytime it needs service, whether the unit is under warranty or not. There is a charge for repairs after the one-year warranty period. Please refer to the Shipping Instructions in this handbook.

The Hewlett-Packard United States Repair Center for handheld and portable printing calculators is located at Corvallis, Oregon. The mailing address is:

HEWLETT-PACKARD COMPANY
CORVALLIS DIVISION, SERVICE DEPT.
P.O. BOX 999
CORVALLIS, OREGON 97330

Note: Not all Hewlett-Packard repair centers offer service for all models of HP calculators. However, you can be sure that service may be obtained in the country where you bought your calculator.

If you happen to be outside of the country where you bought your calculator, you can contact the local Hewlett-Packard repair center to see if service capability is available for your model. If service is unavailable, please ship your calculator to the following address:

Hewlett-Packard
1000 N.E. Circle Boulevard
Corvallis, Oregon 97330
U.S.A.

All shipping and reimportation arrangements are your responsibility.

What Is Not Covered

This warranty does not apply if the product has been damaged by accident or misuse, or as a result of service or modification by other than an authorized Hewlett-Packard repair center.

No other express warranty is given. The repair or replacement of a product is your exclusive remedy. **ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE ONE-YEAR DURATION OF THIS WRITTEN WARRANTY.** Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. **IN NO EVENT SHALL HEWLETT-PACKARD COMPANY BE LIABLE FOR CONSEQUENTIAL DAMAGES.** Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Obligation to Make Changes

Products are sold on the basis of specifications applicable at the time of sale. Hewlett-Packard shall have no obligation to modify or update products once sold.

Warranty Information Toll-Free Number

If you have any questions concerning this warranty please call **800/648-4711.** (In Nevada call 800/992-5710.)

Technical Assistance

Should you need technical assistance concerning calculator applications, etc., call Hewlett-Packard Customer Support at 503/757-2000. This is not a toll-free number, and we regret that we cannot accept collect calls. As an alternative, you may write to:

Hewlett-Packard
Corvallis Division Customer Support
1000 N.E. Circle Boulevard
Corvallis, OR 97330

A great number of our users submit unique key sequences to share with other HP owners. Hewlett-Packard will only consider using ideas given freely to us. Since it is the policy of Hewlett-Packard not to accept suggestions given in confidence, the following statement must be included with your submittal:

"All information stated within is submitted to Hewlett-Packard Company without any confidentiality or obligation. I understand that by forwarding this information, no expressed, implied, or confidential relationship is established with Hewlett-Packard. Hewlett-Packard may copyright, distribute, publish, reproduce, dispose of, or use any or all of the information in any way without compensation to me."

Further Information

Service contracts are not available. Calculator circuitry and design are proprietary to Hewlett-Packard, and service manuals are not available to customers.

Should other problems or questions arise regarding repairs, please call your nearest Hewlett-Packard sales office or repair center.

Appendix B

Error Conditions

Some calculator operations cannot be performed under certain conditions (for example, [÷] when x = 0). If you attempt such an operation under these conditions, the calculator will display the word *Error* followed by a digit, 0 through 3. The following are the operations that cannot be performed under the conditions specified:

Error 0: Improper Mathematical Operation

[÷]	$x = 0$
[y^x]	$y = 0$ and $x \leq 0$, or $y < 0$ and x is noninteger
[$\sqrt{x}$]	$x < 0$
[1/x]	$x = 0$
[LOG]	$x \leq 0$
[LN]	$x \leq 0$
[SIN^{-1}]	$\lvert x \rvert > 1$
[COS^{-1}]	$\lvert x \rvert > 1$
[COSH^{-1}]	$\lvert x \rvert < 1$
[TANH^{-1}]	$\lvert x \rvert > 1$
[Q^{-1}]	$x < 0$ or $x > 1$
[n!]	$x < 0$ or x is noninteger
[STO] [÷]	$x = 0$

Error 1: Storage Register Overflow

[STO] [+] n [STO] [−] n [STO] [×] n [STO] [÷] n [STO] [+] . n [STO] [−] . n [STO] [×] . n [STO] [÷] . n	Magnitude of number in storage register R_n or $R._n$ would be larger than $9.999999999 \times 10^{99}$ as a result of operation.

Error 2: Improper Register Number

STO n RCL n STO + n STO − n STO × n STO ÷ n	$n = 9$
STO . n RCL . n STO + . n STO − . n STO × . n STO ÷ . n	$n \geqslant 6$

Error 3: Improper Statistical Operation

$\bar{x}$	$n = 0$
s	$n \leqslant 1$
r	$n \leqslant 1$
$\hat{x}$	$n \leqslant 1$
$\hat{y}$	$n \leqslant 1$
L.R.	$n \leqslant 1$

Note: *Error 3* is also displayed if division by zero or the square root of a negative number would be required during computation with any of the following formulas:

$$s_x = \sqrt{\frac{M}{n(n-1)}} \qquad s_y = \sqrt{\frac{N}{n(n-1)}} \qquad r = \frac{P}{\sqrt{M \cdot N}}$$

$$A = \frac{P}{M} \qquad B = \frac{M\Sigma y - P\Sigma x}{n \cdot M}$$

(A and B are the values returned by the operation [L.R.], where $y = Ax + B$.)

$$\hat{x} = \frac{P\Sigma x + M(n \cdot y - \Sigma y)}{n \cdot P} \qquad \hat{y} = \frac{M\Sigma y + P(n \cdot x - \Sigma x)}{n \cdot M}$$

where:

$M = n\Sigma x^2 - (\Sigma x)^2$

$N = n\Sigma y^2 - (\Sigma y)^2$

$P = n\Sigma xy - \Sigma x\Sigma y$

Error 9: **Self-Check Failure**

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