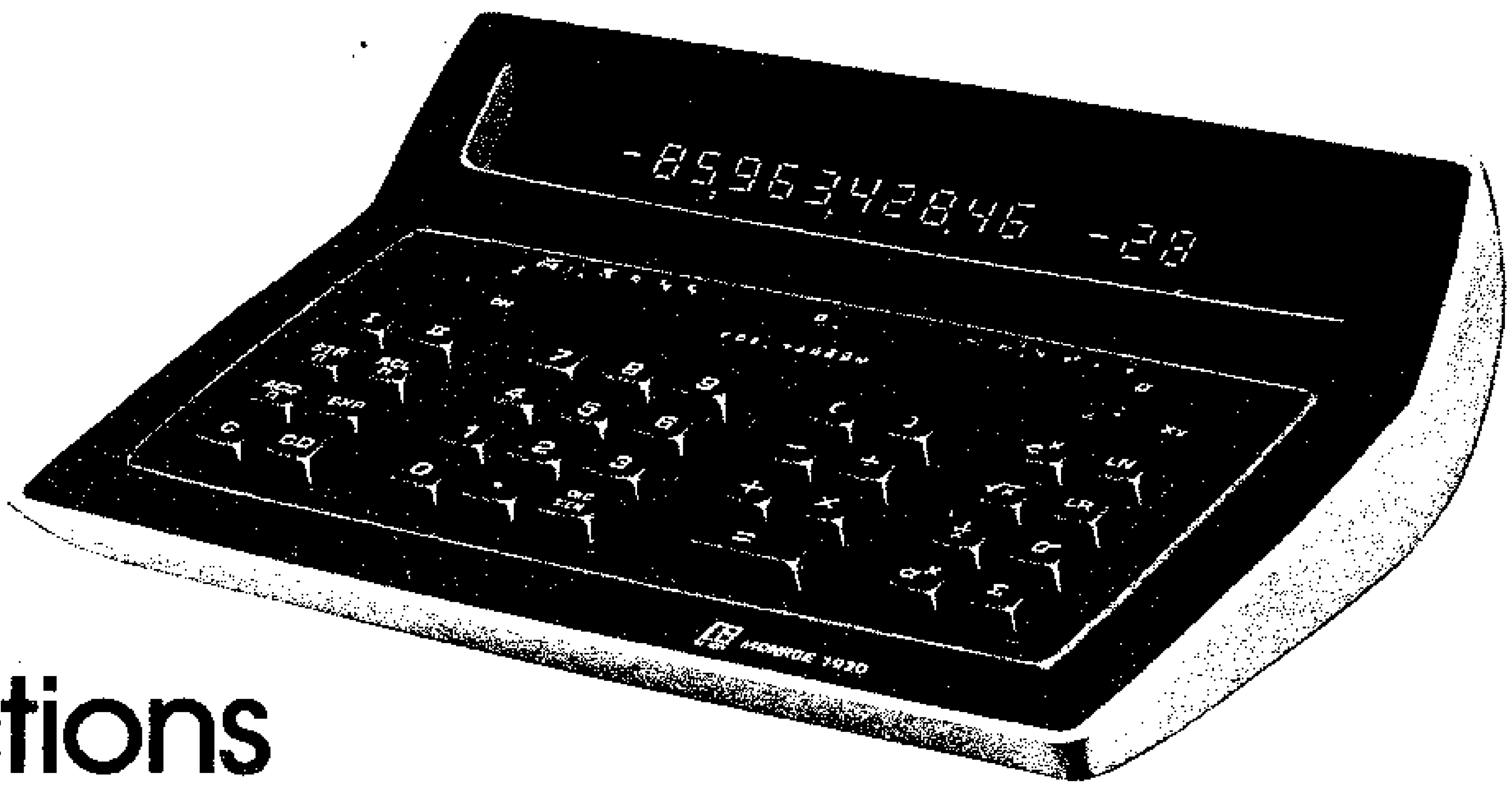
$$\sigma = \sqrt{\frac{\sum x^2 - (\sum x)^2/N}{N-1}}$$

$$m = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sum (x-\bar{x})^2}$$

$$x^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$



# Operating Instructions

# Model 1930

## electronic display calculator for statistics

Litton MONROE

Monroe, The Calculator Company

## BASIC SPECIFICATIONS

**Electronic Display Calculator**

**Automatic Punctuation**

**Algebraic Sequential Calculating Operation**

**Full Arithmetic Capability in All 10 Storage Registers**

**Automatic Constants for** $+$ $-$ $\times$ $\div$ $a^x$

**Dynamic Range** $\pm 9.999 \ldots \times 10^{\pm 99}$

**Display Reformating to Exponent**

**Floating Minus Sign**

**Leading and Trailing Zero Suppression**

**Electronic Keyboard Interlocks and Rollover**

**Three Levels of Parentheses**

**Functions**

$\sqrt{x}$ $1/x$ $a^x$ $Log_{10}$ $Log_e$ $e^x$ $n!$

Ratio of Factorials, Permutations and Combinations

Single-Variable Ungrouped Data Summation

Single-Variable Grouped Data Summation

Two-Variable Data Summation

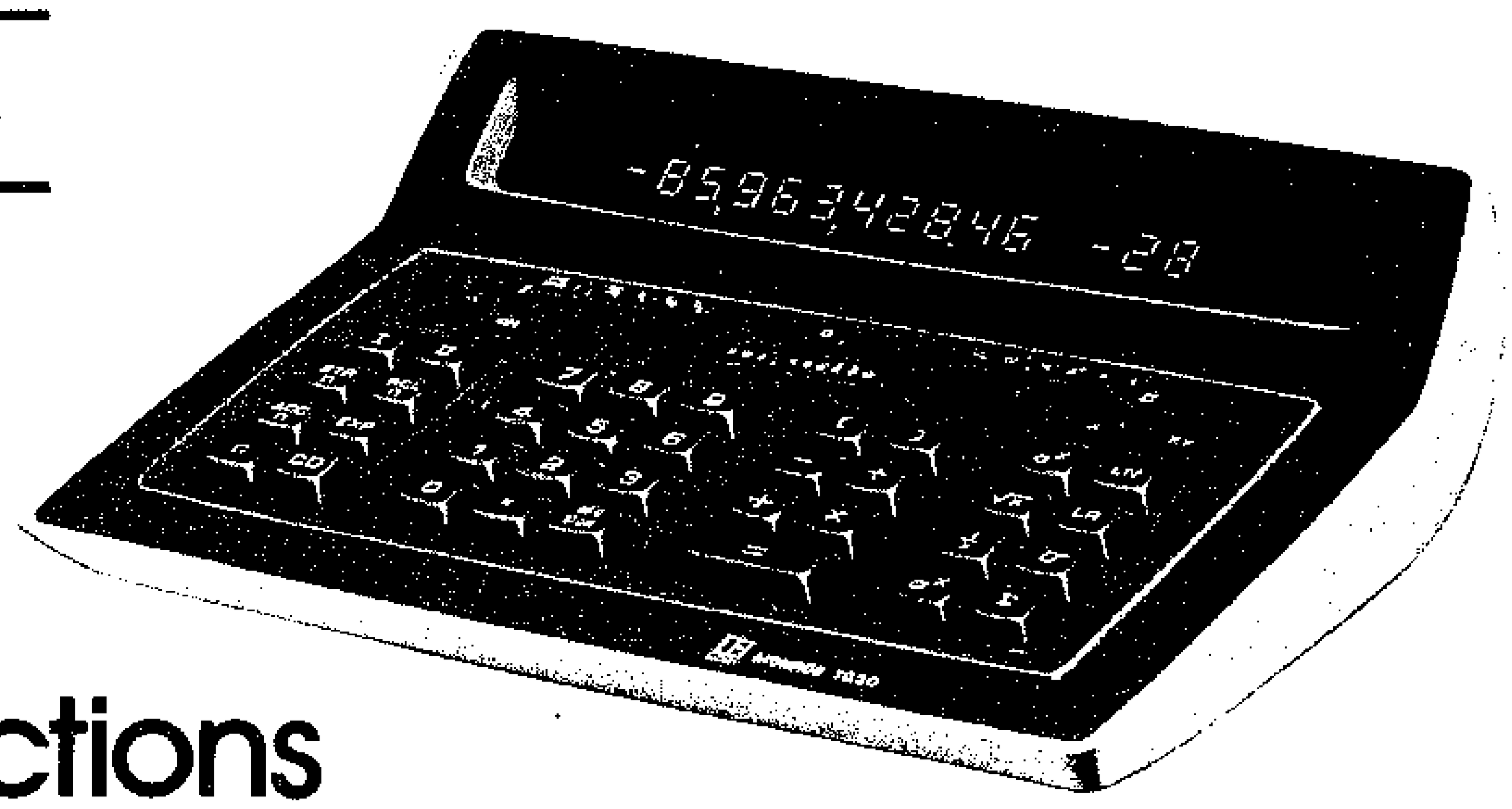
$\sigma$, $\bar{x}$, Standard Error of the Mean, Linear Regression

t-Test, t-Dependent, t-Independent

Student's t, $X^2$, F distributions

The Model 1930 can be adjusted to provide U. S. or European punctuation at the user's option. For further details consult your local Monroe office.

$$\sigma = \sqrt{\frac{\sum x^2 - (\sum x)^2/N}{N-1}}$$



# Operating Instructions

# Model 1930

## electronic display calculator

## for statistics

### INTRODUCTION

Speed . . . accuracy . . . efficiency — these were Monroe's objectives in developing a truly fine statistical calculator — the Model 1930.

Now, as always, Monroe's objectives are your advantages. As you become acquainted with the 1930's many problem-solving capabilities it will become evident that this new Monroe was designed with your unique calculating requirements in mind. But more than this, Monroe's 60-plus years of calculator experience taught us that no matter what the job, calculator users want a product that not only solves problems but provides ease, simplicity, and convenience. We are sure you will experience these sometimes-overlooked factors during the many years of long and dependable service your 1930 will give you.

And, we're prepared to prove this in 365 cities throughout the United States and Canada. We'll do our utmost to make sure that owning and operating a Monroe will be a most rewarding experience, today and tomorrow.

Litton MONROE

Monroe, The Calculator Company

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## TABLE OF CONTENTS

# operating controls

**SPECIAL FUNCTION SWITCH I**
Allows selection of the following functions:

Calculation of t-test to find the significance of the correlation coefficient

Calculation of t-statistic for two dependent samples (paired observations)

Calculation of t-statistic for two independent samples

Calculation of permutations and combinations

Calculation of ratio of factorials

Clearing of registers 0, 1, 2, 3, 4, 5, and 6 to zero

**POWER SWITCH**
Turns calculator on and clears all registers to zero

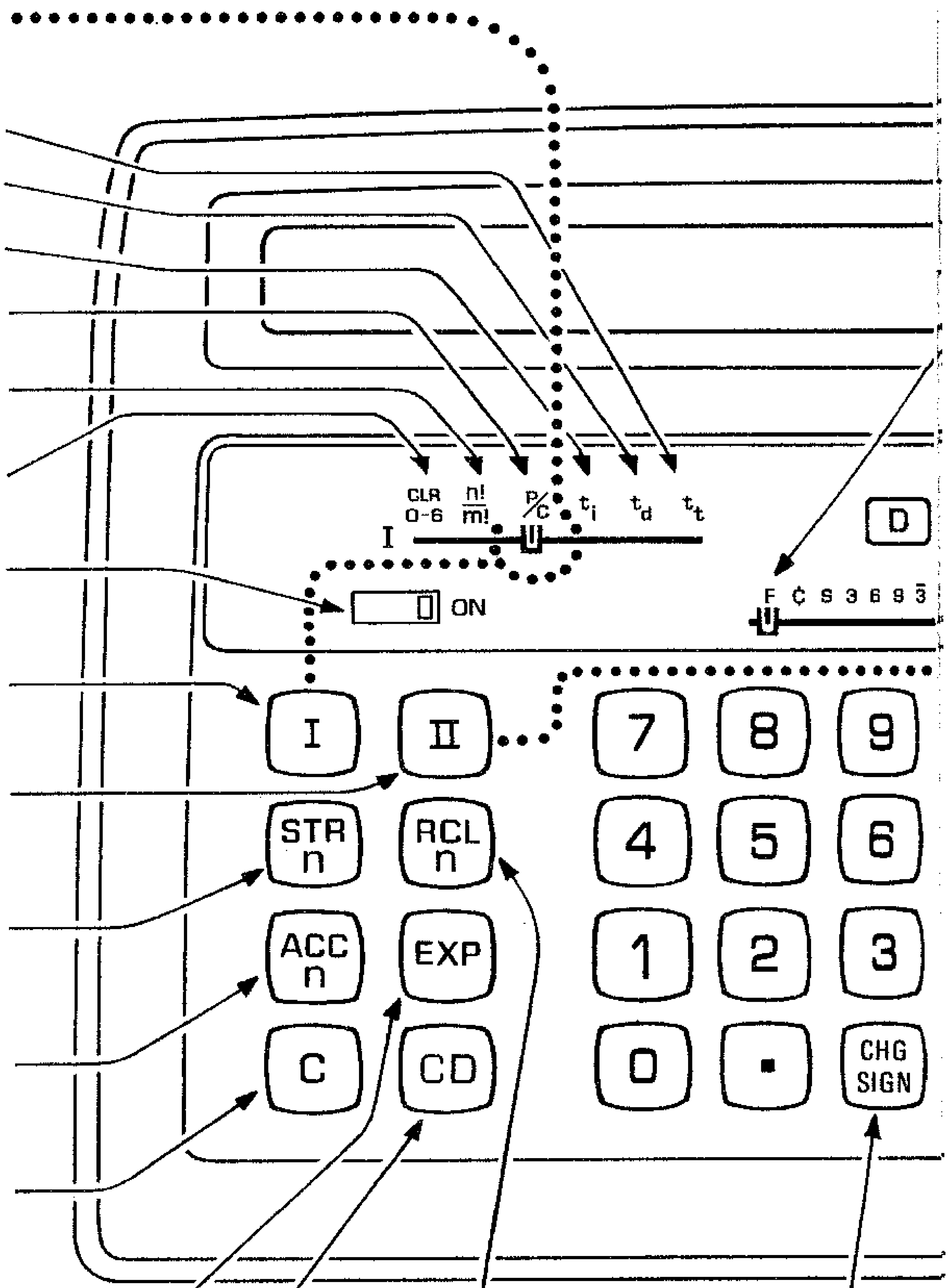
**SPECIAL FUNCTION KEY I**
Executes the function indicated by the position of SPECIAL FUNCTION SWITCH I

**SPECIAL FUNCTION KEY II**
Executes the function indicated by the position of SPECIAL FUNCTION SWITCH II

**STORE KEY**
Stores contents of display into a selected storage register (0-9)

**ACCUMULATE KEY**
Adds contents of the display to the contents of a selected storage register (0-9)

**CLEAR KEY**
Clears the calculator for a new calculation. Does not clear storage registers



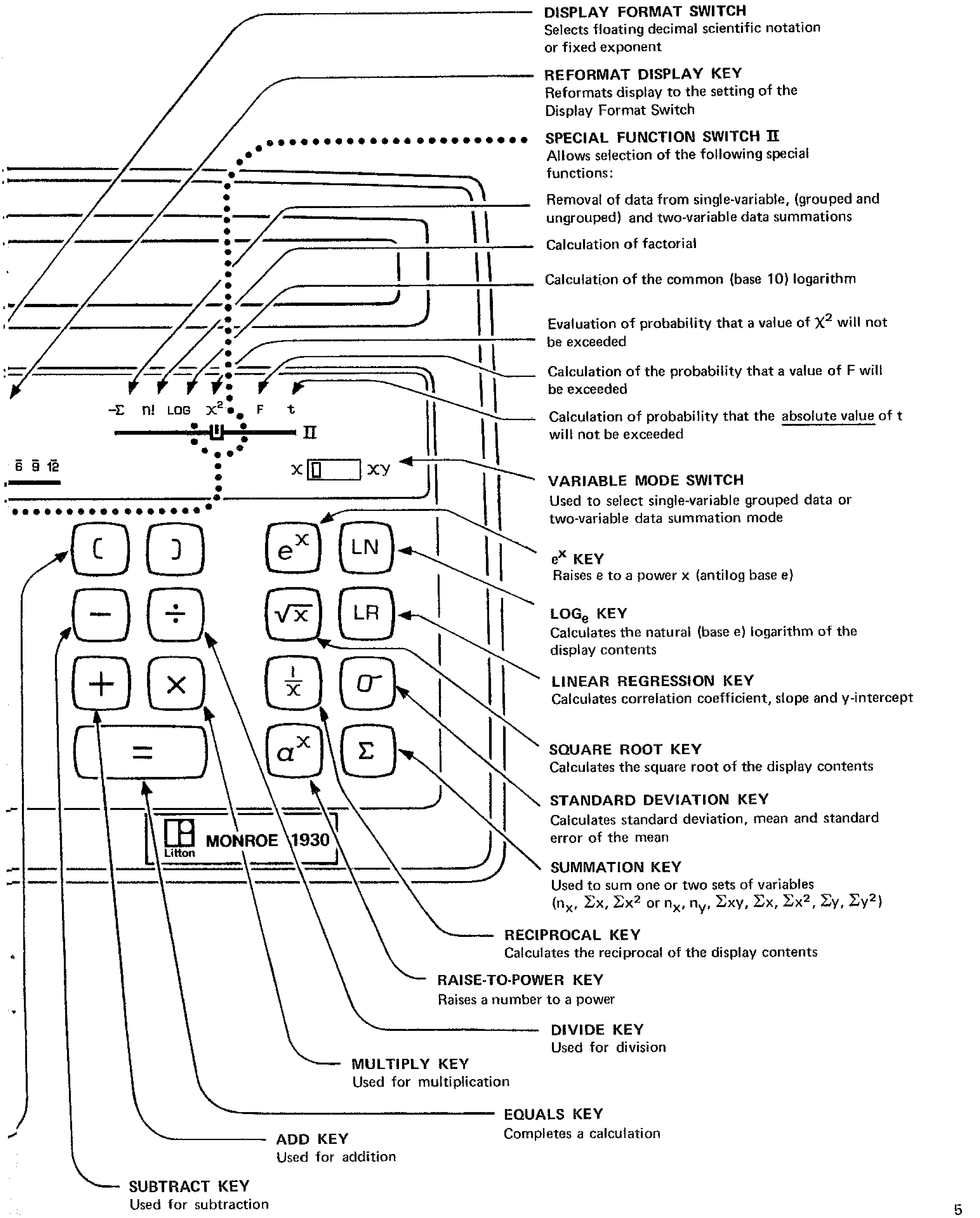

**EXPONENT KEY**
Allows entry of exponent

**CLEAR DISPLAY KEY**
Clears the display to zero

**RECALL KEY**
Recalls contents of a selected storage register (0-9) into the display

**CHANGE SIGN KEY**
Reverses the algebraic sign of the display contents

**PARENTHESES KEY**
Used in algebraic calculations to perform 1, 2 and 3-level sequences


DISPLAY FORMAT SWITCH
Selects floating decimal scientific notation or fixed exponent
REFORMAT DISPLAY KEY
Reformats display to the setting of the Display Format Switch
SPECIAL FUNCTION SWITCH II
Allows selection of the following special functions:
Removal of data from single-variable, (grouped and ungrouped) and two-variable data summations
Calculation of factorial
Calculation of the common (base 10) logarithm
Evaluation of probability that a value of χ² will not be exceeded
Calculation of the probability that a value of F will be exceeded
Calculation of probability that the absolute value of t will not be exceeded
-Σ n! LOG χ² F t
II
6 9 12
x xy
VARIABLE MODE SWITCH
Used to select single-variable grouped data or two-variable data summation mode
( ) eˣ LN
− ÷ √x LR
+ × 1/x σ
= aˣ Σ
eˣ KEY
Raises e to a power x (antilog base e)
LOGₑ KEY
Calculates the natural (base e) logarithm of the display contents
LINEAR REGRESSION KEY
Calculates correlation coefficient, slope and y-intercept
SQUARE ROOT KEY
Calculates the square root of the display contents
STANDARD DEVIATION KEY
Calculates standard deviation, mean and standard error of the mean
SUMMATION KEY
Used to sum one or two sets of variables
(nₓ, Σx, Σx² or nₓ, nᵧ, Σxy, Σx, Σx², Σy, Σy²)
Litton MONROE 1930
RECIPROCAL KEY
Calculates the reciprocal of the display contents
RAISE-TO-POWER KEY
Raises a number to a power
DIVIDE KEY
Used for division
MULTIPLY KEY
Used for multiplication
EQUALS KEY
Completes a calculation
ADD KEY
Used for addition
SUBTRACT KEY
Used for subtraction

[C] Clears display and any algebraic sequence in progress.
Does not clear storage registers, 0-9.

[CD] Clears display only.

[CHG SIGN] Reverses the algebraic sign of the number in the display.
For example, to enter -12, depress [CHG SIGN] [1] [2] or [1] [2] [CHG SIGN]

[EXP] Permits entry of power-of-ten exponent (to ± 99).
For example, to enter $2.3 \times 10^{-19}$, depress [2] [•] [3] [EXP] [CHG SIGN] [1] [9]

Error Appears in the display when an incorrect mathematical operation is attempted.
To clear, depress [C] or [CD]

Operations causing Error

| | |
|---|---|
| Division by 0 | Permutations & combinations, n non-integer |
| Square root of -x | Close parenthesis without open parenthesis |
| For $a^x$, $0^{-x}$, $0^0$ or $a < 0$, x is non-integer | Equals key depression after open parenthesis and before close parenthesis |
| Standard deviation or linear regression with n = 0 or 1 | More than 3 open parentheses without a closed parenthesis |
| Factorial of $n < 1$ or non-integer n | |
| Ratio of Factorial for n or $m < 1$, or non-integer n or m | For $\log_{10}x$, $\log_e x$: $x \leq 0$ |

OFLO appears in the display when an entry or result lies outside the dynamic range of the calculator: $\pm 9.999 \ldots \times 10^{\pm 99}$.
To clear, depress [C] or [CD]

The examples in this manual are based on the floating point setting of the Display Format Switch ( F C S 3 6 9 3 6 9 12 ) *unless otherwise specified.* Therefore, set your Display Format Switch to F.

## ADDITION/SUBTRACTION

| Examples | Enter | Depress | Read |
|---|---|---|---|
| 8 + 4 - 3 | 8 | [+] | 8. |
| | 4 | [−] | 12. |
| | 3 | [=] | 9. |
| 36 + $60 \times 10^5$ - .002 | 36 | [+] | 36. |
| | $60 \times 10^5$ | [−] | 6000036. |
| | .002 | [=] | 6000035.998 |

## MULTIPLICATION

| Example | Enter | Depress | Read |
|---|---|---|---|
| $-8 \times 4 \times 10^{-15}$ | -8 | [×] | -8. |
| | $4 \times 10^{-15}$ | [=] | -3.2 -14 |

Numbers can be multiplied by a constant multiplier without re-entry of the multiplier.

| Example | Enter | Depress | Read |
|---|---|---|---|
| 2 x 3 =<br>2 x 4 =<br>2 x 5 = | 2 | [×] | 2. |
| | 3 | [=] | 6. |
| | 4 | [=] | 8. |
| | 5 | [=] | 10. |

Numbers can be squared without re-entering the number, by depressing [×] [=], or [×] followed by another algebraic key such as [+] or [−]

| Examples | Enter | Depress | Read |
|---|---|---|---|
| $2.5^2$ | 2.5 | [×] [=] | 6.25 |
| $2.5^2 + 6$ | 2.5 | [×] [+] | 6.25 |
| | 6 | [=] | 12.25 |

## DIVISION

| Example | Enter | Depress | Read |
|---|---|---|---|
| $\frac{8.05 \times .333}{9 \times 1.08}$ | 8.05 | × | 8.05 |
| | .333 | ÷ | 2.68065 |
| | 9 | ÷ | 0.29785 |
| | 1.08 | = | 0.2757870370 |

Numbers can be divided by a constant divisor without re-entry of the divisor.

| Example | Enter | Depress | Read |
|---|---|---|---|
| $\frac{180.6 \times 10^{12}}{6.02 \times 10^{23}}$ (6.02 x 10²³: Constant Divisor) | $180.6 \times 10^{12}$ | ÷ | 1.806 14 |
| | $6.02 \times 10^{23}$ | = | 3. -10 |
| $\frac{18.06 \times 10^{12}}{6.02 \times 10^{23}}$ | $18.06 \times 10^{12}$ | = | 3. -11 |

## EXPRESSIONS BETWEEN PARENTHESES

[ ( ] and [ ) ] permits calculation of terms within parentheses up to three levels. More than three [ ( ] without a [ ) ] causes [ Error ]

| Example | Enter | Depress | Read |
|---|---|---|---|
| $\frac{3.5 + 7.2}{8.3 - 2.7}$ | 3.5 | + | 3.5 |
| | 7.2 | ÷ ( | 10.7 |
| | 8.3 | − | 8.3 |
| | 2.7 | ) | 5.6 |
| | | = | 1.910714286 |

Continued

| Example | Enter | Depress | Read |
|---|---|---|---|
| $\frac{9.2+4.5}{6.3+7.1} - \frac{4.9}{1.7}$ | 9.2 | [+] | 9.2 |
| | 4.5 | [÷] [(] | 13.7 |
| | 6.3 | [+] | 6.3 |
| | 7.1 | [)] | 13.4 |
| | | [−] [(] | 1.02238806 |
| | 4.9 | [÷] | 4.9 |
| | 1.7 | [)] | 2.882352941 |
| | | [=] | -1.859964881 |

## SEQUENTIAL CALCULATIONS

Depression of [+] [−] [×] [÷] or [$a^x$] completes any prior operation in progress exactly as if [=] were depressed. The intermediate result is displayed.

| Examples | Enter | Depress | Read |
|---|---|---|---|
| 2 + 3 x .5 = | 2 | [+] | 2. |
| | 3 | [×] | 5. |
| | .5 | [=] | 2.5 |
| $[2 + 3 \times .5]^4$ = | 2 | [+] | 2. |
| | 3 | [×] | 5. |
| | .5 | [$a^x$] | 2.5 |
| | 4 | [=] | 39.0625 |

## ALGEBRAIC FUNCTION KEYS

These keys are used to raise numbers to powers, and to calculate reciprocals and roots of numbers.

### Raising a Number to a Power

| Examples | Enter | Depress | Read |
|---|---|---|---|
| $3.2^5$ | 3.2 | [$a^x$] | 3.2 |
| | 5 | [=] | 335.54432 |
| $7.4^{1.2} + 8.6^{-1.2}$ | 7.4 | [$a^x$] | 7.4 |
| | 1.2 | [+] [(] | 11.04277094 |
| | 8.6 | [$a^x$] | 8.6 |
| | -1.2 | [)] | 0.075613938 |
| | | [=] | 11.11838488 |

A constant base a can be raised to different powers, x

| Examples | Enter | Depress | Read |
|---|---|---|---|
| $3^2$ | 3 | [$a^x$] [2] [=] | 9. |
| $3^3$ | | [3] [=] | 27. |
| $3^4$ | | [4] [=] | 81. |

### Reciprocal

| Examples | Enter | Depress | Read |
|---|---|---|---|
| 1/47.3 | 47.3 | [$\frac{1}{x}$] | 0.021141649 |
| $\frac{1}{5+3}$ | 5 | [+] | 5. |
| | 3 | [=] | 8. |
| | | [$\frac{1}{x}$] | 0.125 |

### Root of a Number

| Example | Enter | Depress | Read |
|---|---|---|---|
| $\sqrt[5]{32}$ | 32 | [$a^x$] | 32. |
| | 5 | [$\frac{1}{x}$] | 0.2 |
| | | [=] | 2. |

*Continued*

## Square Root

| Examples | Enter | Depress | Read |
|---|---|---|---|
| $\sqrt{25}$ | 25 | [√x] | 5. |
| $\sqrt{4^2 - (4 \times 2.1 \times 1.21)}$ | 4 | [×] [–] [(] | 16. |
| | 4 | [×] | 4. |
| | 2.1 | [×] | 8.4 |
| | 1.21 | [)] | 10.164 |
| | | [=] | 5.836 |
| | | [√x] | 2.415781447 |

## Natural Logarithm (Base e)

| Examples | Enter | Depress | Read |
|---|---|---|---|
| $\text{Log}_e$ 17.2 | 17.2 | [LN] | 2.844909384 |
| $\text{Log}_e$ 0.00123 | .00123 | [LN] | -6.70074111 |

## $e^x$ (Antilog$_e$)

| Example | Enter | Depress | Read |
|---|---|---|---|
| Antilog$_e$ 2.8 | 2.8 | [eˣ] | 16.44464677 |

## Common Logarithm (Base 10)

| Example | Set | Enter | Depress | Read |
|---|---|---|---|---|
| $\text{Log}_{10}$ 3.1 | [LOG / II] | 3.1 | [II] | 0.491361694 |

Setting on Special Function Switch II. Execute the function by depressing [II].

## STORAGE REGISTERS

The Model 1920 contains ten storage registers, numbered 0 through 9, for storing data. All ten registers are cleared to zero when the calculator is turned on. Individual registers can be cleared by storing a zero in the register.

### Storing a Number

Numbers can be stored in a register by depressing [STR n] followed by n, the register number. The previous contents of the register are automatically replaced.

| Example | Enter | Depress | Read | No. | Contents |
|---|---|---|---|---|---|
| Store 128.4 into register 6 | 128.4 | [STR n] [6] | 128.4 | 6 | *128.4* |
| Store the result of 3.1 x 123 in register 0 | 3.1 | [×] | 3.1 | | |
| | 123 | [=] [STR n] [0] | 381.3 | 0 | *381.3* |

Continued

## Recalling a Number

Numbers can be recalled from a register by depressing [RCL n] followed by n, the register number.

**Example**

| | Depress | Read | Registers No. | Registers Contents |
|---|---|---|---|---|
| Recall contents of register 6 | [RCL n] [6] | 128.4 | 6 | *128.4* |
| Recall contents of register 0 | [RCL n] [0] | 381.3 | 0 | *381.3* |

## Storing and Recalling Numbers

Store and recall may be executed as often as necessary to aid in the solution of a problem.

**Example**

Find $$\frac{28(2.12469^{1.203})}{14(2.12469^{1.203}) - LN(2.12469^{1.203})}$$

Method: Since $2.12469^{1.203}$ appears in three places, it may be calculated once and stored as a constant.

| Enter | Depress | Read |
|---|---|---|
| 2.12469 | [$a^x$] | 2.12469 |
| 1.203 | [=] | 2.475919814 |
| | [STR n] [1] | 2.475919814 |
| | [×] | 2.475919814 |
| 28 | [÷] [(] | 69.32575479 |
| 14 | [×] [RCL n] [1] [−] | 34.66287774 |
| | [RCL n] [1] [LN] [)] | 33.75626543 |
| | [=] | 2.053715182 |

## Accumulating Numbers

Accumulate numbers in a register by depressing [ACC n] followed by the register number.

**Example**

| | Enter | Depress | Read | Register 2 Contents |
|---|---|---|---|---|
| Accumulate 10, 25 and -6 in register 2 | 10 | [STR n] [2] | 10. | *10* |
| | 25 | [ACC n] [2] | 25. | *35* |
| | -6 | [ACC n] [2] | -6. | *29* |
| | | [RCL n] [2] | 29. | *29* |

## REGISTER ARITHMETIC

Addition, subtraction, multiplication and division can be performed with the contents of any one of the ten registers and display as follows:

### Results Stored

| Operation | Depress | |
|---|---|---|
| Add displayed number to register contents | [STR n] [+] | Result In Register n |
| Subtract displayed number from register contents | [STR n] [−] | |
| Multiply register contents by displayed number | [STR n] [×] | |
| Divide register contents by display number | [STR n] [÷] | |

| Examples | Enter | Depress | Read | Register 2 Contents |
|---|---|---|---|---|
| ADDITION | | | | |
| Add 7 to 29 in register 2 (Store 29 into register 2 if it isn't already stored from the prior example.) | 7 | [STR n] [+] [2] | 7. | 36 |
| | | [RCL n] [2] | 36. | 36 |
| SUBTRACTION | | | | |
| Subtract 14 from 36 in register 2 | 14 | [STR n] [−] [2] | 14. | 22 |
| | | [RCL n] [2] | 22. | 22 |
| MULTIPLICATION | | | | |
| Multiply 22 in register 2 by 4 | 4 | [STR n] [×] [2] | 4. | 88 |
| | | [RCL n] [2] | 88. | 88 |
| DIVISION | | | | |
| Divide 88 in register 2 by 8 | 8 | [STR n] [÷] [2] | 8. | 11 |
| | | [RCL n] [2] | 11. | 11 |

### Results Displayed

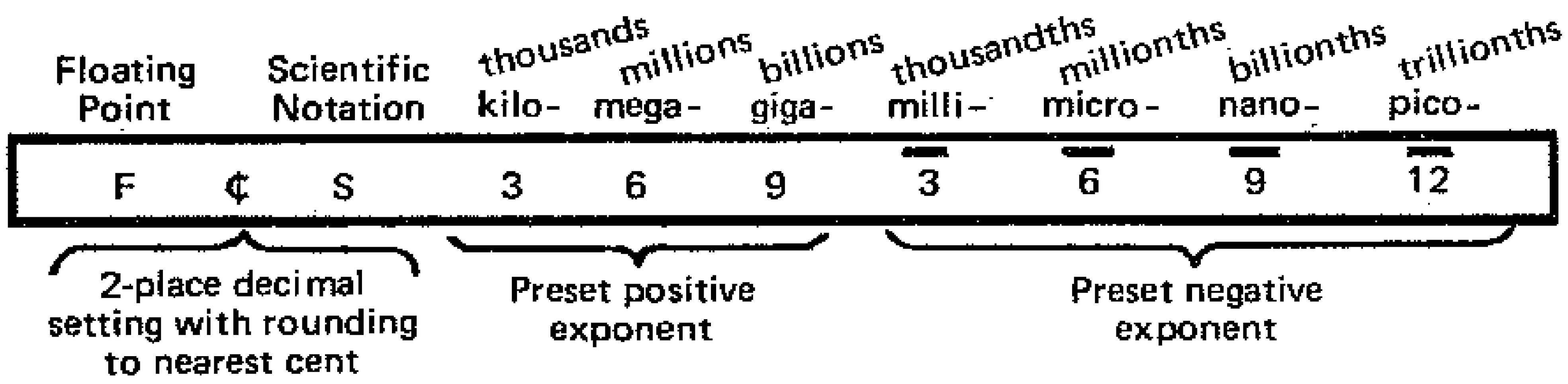
| Operation | Depress | |
|---|---|---|
| Add register contents to display number | [RCL n] [+] | Result In Display |
| Subtract register contents from display number | [RCL n] [−] | |
| Multiply displayed number by register contents | [RCL n] [×] | |
| Divide displayed number by register contents | [RCL n] [÷] | |

| | | | |
|---|---|---|---|
| **ADDITION**<br>Add 11 in register 2 (from prior example) to 17 in the display | 17 | RCL n + 2 | 17<br>28. |
| **SUBTRACTION**<br>Subtract 11 (in register 2) from 28 in display register | | RCL n − 2 | 17. |
| **MULTIPLICATION**<br>Multiply 17 in the display register by 11 in register 2 | | RCL n × 2 | 187. |
| **DIVISION**<br>Divide 187 in the display register by 11 in register 2 | | RCL n ÷ 2 | 17. |

## DISPLAY FORMAT

### Display Format Switch

The Display Format Switch permits final results (results following = depression) to be displayed in any selected format as follows:




Note: When the display capacity of the calculator is exceeded, the number is automatically displayed in scientific notation.

| Examples | Set | Enter | Depress | Read |
|---|---|---|---|---|
| $21.33 ÷ $4.20 |  | 21.33 | ÷ | 21.33 |
| | | 4.2 | = | 5.08 |
| Find 7.25 grams x 119.3 in kilograms |  | 7.25 | × | 7.25 |
| | | 119.3 | = | 0.864925 3 |
| Find 14.27 liters ÷ 3.2 in milliliters |  | 14.27 | ÷ | 14.27 |
| | | 3.2 | = | 4.459375 - 3 |

### D Key

To reformat a displayed number, change the Display Format Switch to desired setting and depress D

Example: Reformat 4.459375 - 3 to floating point format.

| Set | Depress | Read |
|---|---|---|
|  | D | 4.459375 |

## STATISTICS FUNCTIONS

12 additional functions are available by positioning Special Function Switches I or II under the function needed. The function is executed by depression of [I] or [II], whichever key is appropriate. These function switches are shown below and are discussed throughout the manual.

I: CLR 0-6 | n!/m! | P/C | $t_i$ | $t_d$ | $t_t$

II: -Σ | n! | LOG | $x^2$ | F | t

---

### Factorial

Factorial of a number larger than 69 causes OFLO

Factorial of a non-integer or a negative number causes Error

| Example | Set | Enter | Depress | Read |
|---|---|---|---|---|
| 12! | n! | 12 | II | 479001600. |

### Ratio of Factorials

If either number in the ratio is negative or a non-integer, an error will result.

| Example | Set | Enter | Depress | Read |
|---|---|---|---|---|
| $\frac{12!}{10!}$ | n!/m! | 12 (n) | I | 12. |
| | | 10 (m) | = | 132. |

### Permutations and Combinations

Calculates the number of permutations and combinations of n items taken r at a time. The number of permutations is displayed and stored in register 9. The number of combinations is stored in register 8. Permutations (P) and combinations (C) are defined by the following formulas:

$$P = \frac{n!}{(n-r)!} \qquad C = \frac{n!}{r!\,(n-r)!}$$

Example: Find the number of permutations and combinations of 12 items taken 4 at a time.

| Set | Enter | Depress | Read | |
|---|---|---|---|---|
| P/C | 12 (n) | I | 12. | |
| | 4 (r) | = | 11,880. | (permutations) |
| | | RCL n 8 | 495. | (combinations) |

### Variable Mode Switch

Switch must be in the x position for single-variable grouped data summations and in the xy position for two variable data summations. It may be in either position for single-variable ungrouped data summations.

Single-Variable Grouped Data Summation [x ▮ xy] (see page 17)

Two-Variable Data Summation [x ▮ xy] (see page 18)

## Single-Variable Ungrouped Data Summation

To perform a single-variable summation, enter x and depress [Σ] Summed values are stored as follows:

| Register | 1 | 2 | 3 |
|---|---|---|---|
| Data | n | $\Sigma x$ | $\Sigma x^2$ |

| Example | Set | Enter | Depress | Read | Register Contents No. 1 | No. 2 | No. 3 |
|---|---|---|---|---|---|---|---|
| Perform a summation for terms 3, -4, -1 | * [CLR 0-6] | | [I] | | 0 | 0 | 0 |
| | [x ▢ xy] | 3 | [Σ] | 3. | 1 | 3 | 9 |
| | | -4 | [Σ] | -4. | 2 | -1 | 25 |
| | | -1 | [Σ] | -1. | 3 | -2 | 26 |
| | | | [RCL n] [1] | 3. | | | |
| | | | [RCL n] [2] | -2. | | | |
| | | | [RCL n] [3] | 26. | | | |

*With Special Function Switch I [CLR 0-6 | n!/m! | %/c | $t_i$ | $t_d$ | $t_t$] in position shown, depression of [I] clears registers 0 through 6.

## Single-Variable Ungrouped Data Removal

Removes unwanted data from a single-variable data summation. The adjusted register contents for removal of $x_i$ data are:

| Register | 1 | 2 | 3 |
|---|---|---|---|
| Data | n − 1 | $\Sigma x - x_i$ | $\Sigma x^2 - x_i^2$ |

Note: Further data may be entered after unwanted data is removed.

Example: Remove −4 from the previous (single-variable ungrouped data) summation. Find the new n, $\Sigma x$, $\Sigma x_2^2$.

| Set | Enter | Depress | Read | Register Contents No. 1 | No. 2 | No. 3 |
|---|---|---|---|---|---|---|
| [−Σ] | −4 | [II] | -4. | 2 | 2 | 10 |
| | | [RCL n] [1] | 2. | | | |
| | | [RCL n] [2] | 2. | | | |
| | | [RCL n] [3] | 10. | | | |

## Single-Variable Grouped Data Summation

Perform a summation for data grouped with frequency, f. Results are stored as follows:

| Register | 1 | 2 | 3 |
|---|---|---|---|
| Data | n | $\Sigma x$ | $\Sigma x^2$ |

| Example | Set | Enter | Depress | Read | Register Contents No. 1 | No. 2 | No. 3 |
|---|---|---|---|---|---|---|---|
| Perform a grouped-data summation for: | CLR 0-6 | | I | | 0 | 0 | 0 |
| | X ▯ XY | 5 | Σ | 5. | | | |
| x / f: 5 / 2 | | 2 | = | 2. | 2 | 10 | 50 |
| −3 / 4 | | −3 | Σ | -3. | | | |
| 2 / 3 | | 4 | = | 4. | 6 | −2 | 86 |
| | | 2 | Σ | 2. | | | |
| | | 3 | = | 3. | 9 | 4 | 98 |
| | | | RCL n 1 | 9. | | | |
| | | | RCL n 2 | 4. | | | |
| | | | RCL n 3 | 98. | | | |

## Single-Variable Grouped Data Removal

Removes unwanted data from single-variable grouped data summation. The adjusted register contents for removal of $x_i$, $f_i$ data are:

| Register | 1 | 2 | 3 |
|---|---|---|---|
| Data | $n - f_i$ | $\Sigma x - f_i x_i$ | $\Sigma x^2 - f_i x_i^2$ |

Note: Further data may be entered after unwanted data is removed.

Example: Remove −3 with a frequency of 4 from the previous (single-variable grouped data) summation. Find new n, $\Sigma x$ and $\Sigma x^2$.

| Set | Enter | Depress | Read | Register Contents No. 1 | No. 2 | No. 3 |
|---|---|---|---|---|---|---|
| X ▯ XY | | | | | | |
| −Σ | −3 | II | -3. | | | |
| | 4 | = | 4. | 5 | 16 | 62 |
| | | RCL n 1 | 5. | | | |
| | | RCL n 2 | 16. | | | |
| | | RCL n 3 | 62. | | | |

## Two-Variable Data Summation

Performs a two-variable data summation. The summed values are stored as follows:

| Register | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Data | $\Sigma xy$ | $n_x$ | $\Sigma x$ | $\Sigma x^2$ | $n_y$ | $\Sigma y$ | $\Sigma y^2$ |

| Example | Set | Enter | Depress | Read | Register Contents No.0 | No.1 | No.2 | No.3 | No.4 | No.5 | No.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Perform a summation for: | CLR 0-6 | | I | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| x y | X [ ] XY | 4 | Σ | 4. | | | | | | | |
| 4 5 | | 5 | = | 5. | 20 | 1 | 4 | 16 | 1 | 5 | 25 |
| 3 2 | | 3 | Σ | 3. | | | | | | | |
| 5 7 | | 2 | = | 2. | 26 | 2 | 7 | 25 | 2 | 7 | 29 |
| 9 8 | | 5 | Σ | 5. | | | | | | | |
| | | 7 | = | 7. | ~~56~~ 61 | 3 | 12 | 50 | 3 | 13 | 65 |
| | | 9 | Σ | 9. | 133 | 4 | 21 | 131 | 4 | 22 | 142 |
| | | 8 | = | 8. | | | | | | | |
| | | | RCL n 0 | 133. | | | | | | | |
| | | | RCL n 1 | 4. | | | | | | | |
| | | | RCL n 2 | 21. | | | | | | | |
| | | | RCL n 3 | 131. | | | | | | | |
| | | | RCL n 4 | 4. | | | | | | | |
| | | | RCL n 5 | 22. | | | | | | | |
| | | | RCL n 6 | 142. | | | | | | | |

## Two-Variable Data Removal

Removes unwanted data from a two-variable data summation. The adjusted register contents for the removal of $x_i$, $y_i$ are:

| Register | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Data | $\Sigma xy - x_i y_i$ | $n_x - 1$ | $\Sigma x - x_i$ | $\Sigma x^2 - x_i^2$ | $n_y - 1$ | $\Sigma y - y_i$ | $\Sigma y^2 - y_i^2$ |

Note: Further data may be entered after unwanted data is removed.

Example: With results of the two-variable data summation example, page 18, in registers 0-6; remove x = 4, y = 5
Find the new $\Sigma xy$, $n_x$, $\Sigma x$, $\Sigma x^2$, $n_y$, $\Sigma y$, and $\Sigma y^2$

| Set | Enter | Depress | Read | No.0 | No.1 | No.2 | No.3 | No.4 | No.5 | No.6 |
|---|---|---|---|---|---|---|---|---|---|---|
| X [ ] XY | | | | | | | | | | |
| -Σ | 4 | II | 4. | | | | | | | |
| | 5 | = | 5. | | | | | | | |
| | | RCL n 0 | 113. | 113 | 3 | 17 | 115 | 3 | 17 | 117 |
| | | RCL n 1 | 3. | | | | | | | |
| | | RCL n 2 | 17. | | | | | | | |
| | | RCL n 3 | 115. | | | | | | | |
| | | RCL n 4 | 3. | | | | | | | |
| | | RCL n 5 | 17. | | | | | | | |
| | | RCL n 6 | 117. | | | | | | | |

## Standard Deviation, Mean, Standard Error of Mean

Calculates these functions for summed data n, $\Sigma x$ and $\Sigma x^2$ stored in registers 1, 2 and 3, upon depressing [σ]. Standard deviation ($\sigma$) is displayed and stored in register 9. The mean ($\bar{x}$) is stored in register 8 and the standard error of the mean ($S_M$) is in register 7. The formulas are:

$$\sigma = \sqrt{\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n - 1}} \qquad \bar{x} = \frac{\Sigma x}{n} \qquad S_M = \frac{\sigma}{\sqrt{n}}$$

Example: Find $\sigma$, $\bar{x}$, and $S_M$ for the x data of the two-variable data removal example, page 19. If data has been removed from the registers, store as follows:

| Register | 1 | 2 | 3 |
|---|---|---|---|
| Data | 3 | 17 | 115 |

| Depress | Read | |
|---|---|---|
| [σ] | 3.055050463 | ($\sigma$) |
| [RCL n] [8] | 5.666666667 | ($\bar{x}$) |
| [RCL n] [7] | 1.763834207 | ($S_M$) |

## Linear Regression

Upon depressing [LR], correlation coefficient (r), slope (m) and y-intercept (b) are calculated where y = mx + b is the least squares regression equation of y on x. With two-variable summation data stored in registers 0 through 6, r is displayed and stored in register 9, m is stored in register 8 and b is stored in register 7. The formulas are:

$$r = \frac{\Sigma xy - \frac{\Sigma x \, \Sigma y}{n}}{\sqrt{\left(\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right)\left(\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right)}}$$

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

$$b = \frac{\Sigma y - m\Sigma x}{n}$$

*Continued*

Example: Find r, m and b for the two-variable data removal example, page 19; data has been removed from the registers, store as follows:

| Register | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Data | 113 | 3 | 17 | 115 | 3 | 17 | 117 |

| Depress | Read | |
|---|---|---|
| LR | 0.848555292 | (r) |
| RCL n 8 | 0.892857143 | (m) |
| RCL n 7 | 0.607142857 | (b) |

## t-Test

Calculates and displays $t_t$ which is used to test the significance of r, the correlation coefficient of a sample. The $t_t$ statistic is calculated using the equation, $t_t = r\sqrt{\frac{n-2}{1-r^2}}$, with n – 2 degrees of freedom. To execute this function, n must be in register 1 and r must be in the display.

Example: Find $t_t$ for the correlation coefficient (r) of the previous example. If necessary, enter the results of the two-variable data removal example into the calculator as shown above.

| Set | Depress | Read | |
|---|---|---|---|
| $t_t$ | LR | 0.848555292 | (r) |
| | I | 1.603750748 | ($t_t$) |

Example: Calculate t-statistic given r = 0.867 and n = 5

| Set | Enter | Depress | Read |
|---|---|---|---|
| CLR 0-6 n!/m! P/C $t_i$ $t_d$ $t_t$ I | 5 | STR n 1 | 5.0 |
| | .867 | I | 3.013573203 |

## t-Dependent

Calculates and displays the t-statistic for dependent paired data according to the following formula:

$$t_d = \frac{\bar{x} - \bar{y}}{\sqrt{\dfrac{\sigma_x{}^2 + \sigma_y{}^2 - 2r\sigma_x\sigma_y}{n}}}$$

where: $\bar{x} = \dfrac{\Sigma x}{n}$; $\bar{y} = \dfrac{\Sigma y}{n}$; $\sigma_x$ = standard deviation of x; $\sigma_y$ = standard deviation of y;

r = correlation coefficient

The data needed to calculate this statistic must be stored in registers 1 through 6 as follows:

| Register | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Data | $\Sigma xy$ | $n_x$ | $\Sigma x$ | $\Sigma x^2$ | $n_y$ | $\Sigma y$ | $\Sigma y^2$ |

Note: If the correlation coefficient (r) of sample is large, i.e., approaches 1 or −1, the $t_d$ value will exceed machine capacity and **0FLO** will occur.

Example: Find t-dependent for the two-variable data summation example, page 18. Store data as follows:

| Register | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Data | 133 | 4 | 21 | 131 | 4 | 22 | 142 |

| Set | Depress | Read |
|---|---|---|
| $t_d$ | I | -0.333333333 |

## t-Independent

Calculates and displays the t-statistic for independent x and y data according to the following formula:

$$t_i = \frac{\bar{x} - \bar{y}}{\sqrt{\dfrac{(n_x - 1)\,\sigma_x^2 + (n_y - 1)\,\sigma_y^2}{n_x + n_y - 2}\left(\dfrac{1}{n_x} + \dfrac{1}{n_y}\right)}}$$

where $x = \dfrac{\Sigma x}{n_x}$; $y = \dfrac{\Sigma y}{n_x}$; $\sigma_x$ = standard deviation of x sample; $\sigma_y$ = standard deviation of y sample.

The data needed to calculate this statistic must be stored in registers 1 through 6 as follows:

| Register | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Data | $n_x$ | $\Sigma x$ | $\Sigma x^2$ | $n_y$ | $\Sigma y$ | $\Sigma y^2$ |

*Continued*

This data may be entered by three different methods:

1. Two-Variable Data Summation and Σ

- If sample sizes differ, treat the sample with the greater number of terms as x data.
- With the Variable Input Switch on xy , perform a two-variable data summation until the final y value has been entered.
- Perform a single-variable data summation on the remaining x values.

2. Σ

- Enter the y sample using a single-variable data summation. Registers 1, 2, and 3 will hold $n_y$, $\Sigma y$ and $\Sigma y^2$, respectively.
- Transfer these values to registers 4, 5 and 6, respectively, using RCL n and STR n
- Clear registers 1, 2 and 3 by storing zeros in them.
- Perform a single-variable data summation on the x sample.

3. Direct-Data Storage

If known, store $n_x$, $\Sigma x^2$, $n_y$, $\Sigma y$, and $\Sigma y^2$ directly into registers 1 through 6, respectively.

Example: Find $t_i$ for the following data.

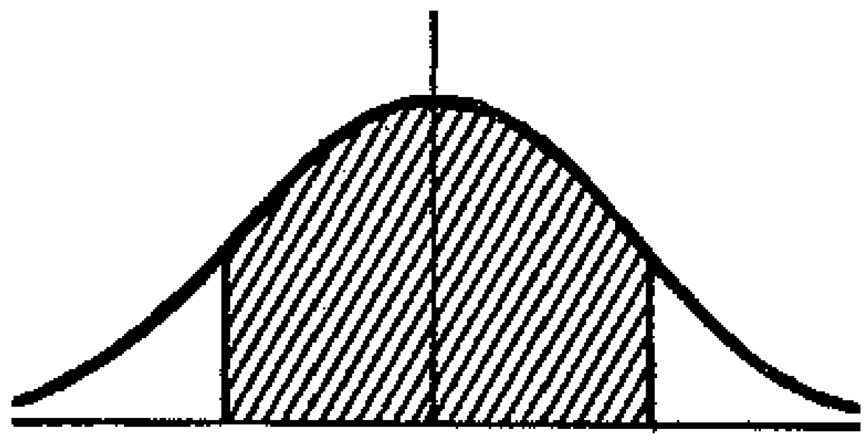
| | | | | | | |
|---|---|---|---|---|---|---|
| x | 30 | 35 | 31 | 34 | 37 | 37 |
| y | 55 | 46 | 51 | | | |

Refer to method 1. Note that the last two data points are entered via grouped data summation. (See page 17 )

| Set | Enter | Depress | Read |
|---|---|---|---|
| CLR 0-6 | | I | |
| x ▯ xy (xy) | 30 | Σ | 30. |
| | 55 | = | 55. |
| | 35 | Σ | 35. |
| | 46 | = | 46. |
| | 31 | Σ | 31. |
| | 51 | = | 51. |
| x ▯ xy (x) | 34 | Σ | 34. |
| | 37 | Σ | 37. |
| | 2 | = | 2. |
| $t_i$ | | I | -6.777297288 |

## Student's t Distribution

For given values of t and degrees of freedom (df), Student's t is used to calculate the probability that the absolute value of t will not be exceeded. That is, it computes the shaded area under the t-curve shown below.

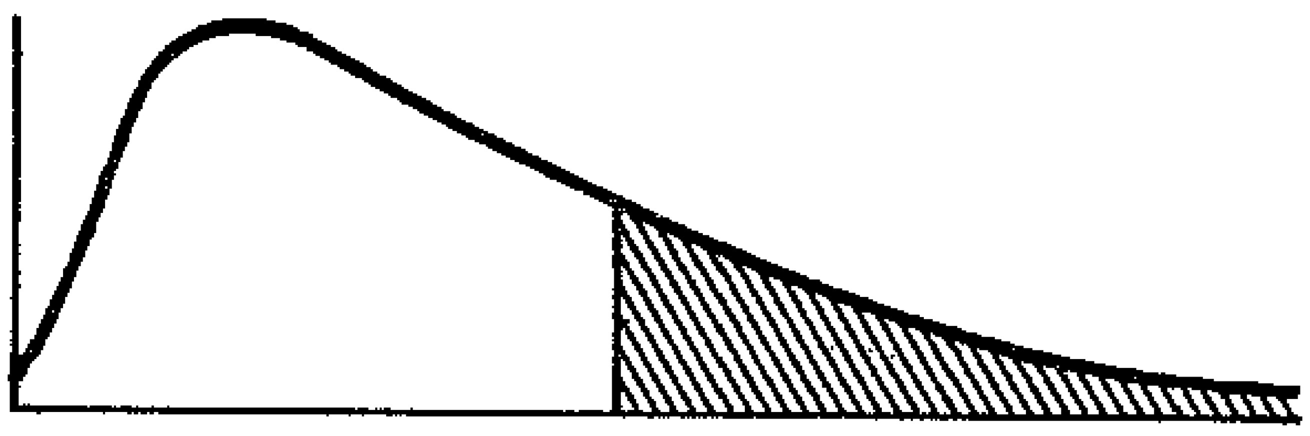



Example: Find the probability, for 3 degrees of freedom, that t lies between -2.32 and + 2.32

| Set | Enter | Depress | Read |
|---|---|---|---|
| t | 2.32 | II | 2.32 |
| | 3 | = | 0.896915811 |

## F Distribution

For a given value of F and degrees of freedom, $df_1$ and $df_2$, the F distribution is used to calculate the probability that the F value will be exceeded. This probability is shown as the shaded area (upper tail) of the F-distribution curve presented below. With reference to the formula $F = \sigma_1^2/\sigma_2^2$, $df_1$ must be stored in register 1 and $df_2$ in register 2.



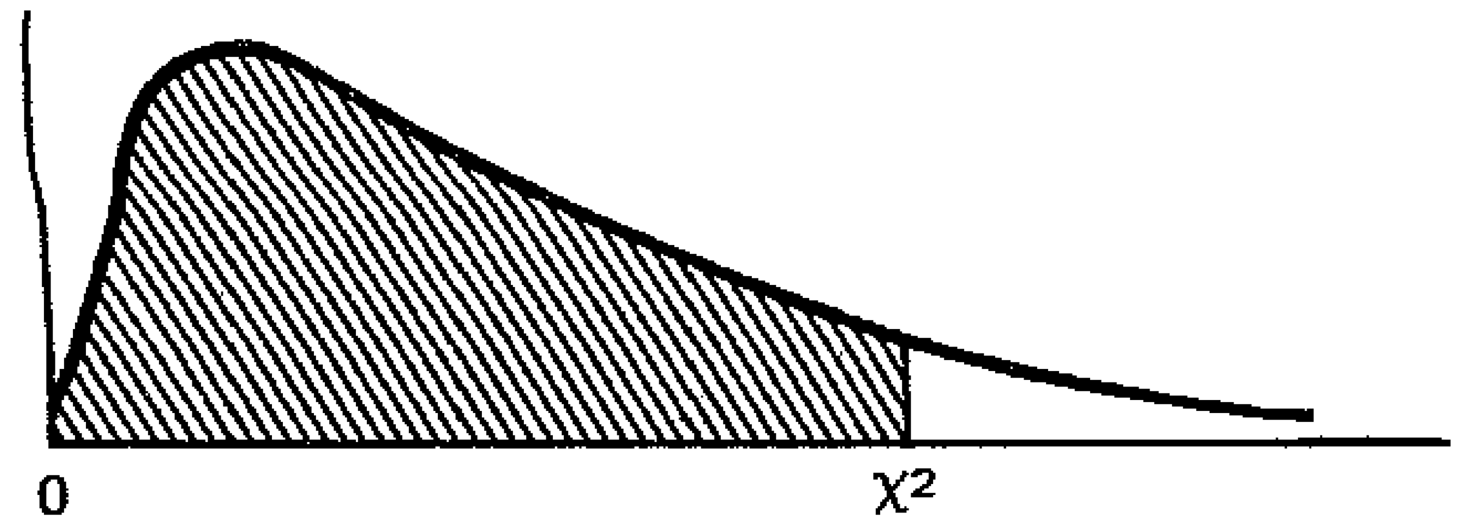

Example: Find the F value and the probability that it will be exceeded, for two sets of data, one with 4 degrees of freedom and a variance ($\sigma_1^2$) of 16.5, the other with 6 degrees of freedom and a variance ($\sigma_2^2$) of 4.3

| Set | Enter | Depress | Read |
|---|---|---|---|
| CLR 0-6 | | I | |
| F | 4 ($df_1$) | STR n 1 | 4. |
| | 6 ($df_2$) | STR n 2 | 6. |
| | 16.5 ($\sigma_1^2$) | ÷ | 16.5 |
| | 4.3 ($\sigma_2^2$) | = | 3.837209302 (F) |
| | | II | 0.070078819 |

## Chi Square Distribution

For a given value of $\chi^2$ and degrees of freedom (df), this function calculates the probability that the $\chi^2$ value will not be exceeded, i.e., the area from 0 to the value of $\chi^2$ is found.

This probability is illustrated by the shaded area of the cumulative chi-square distribution below.




Example: For $\chi^2 = 2.4$ and df = 4, find the probability that $\chi^2$ will not be exceeded.

| Set | Enter | Depress | Read |
|---|---|---|---|
| $x^2$ | 2.4 ($\chi^2$) | II | 2.4 |
| | 4 (df) | = | 0.337372734 |

## Analysis of Independent Samples

| Sample x | Sample y |
|---|---|
| 12 | 10 |
| 15 | 14 |
| 11 | 13 |
| 9 | |
| 14 | |

1. Determine independent t-statistic, $t_i$ .
2. With what level of confidence can we test t-ind.? (For t-ind to be valid, the population variances for x and y must be equal.) An F test, performed for the sample variances, will test this assertion.
3. What is the probability that the absolute value of t-ind will not be exceeded?

| Set | Enter | Depress | Read | Comment |
|---|---|---|---|---|
| CLR 0-6 | | I | | |
| X [ ] XY | 12 | Σ | 12. | |
| | 10 | = | 10. | |
| | 15 | Σ | 15. | |
| | 14 | = | 14. | |
| | 11 | Σ | 11. | |
| | 13 | = | 13. | |
| | 9 | Σ | 9. | |
| | 14 | Σ | 14. | |
| $t_i$ | | I STR n 0 | -0.079724101 | t-independent |
| | | σ | 2.387467277 | $\sigma_x$ (Stored in register 9) |
| | | RCL n 4 STR n 1 | 3. | $n_y$ |
| | | RCL n 5 STR n 2 | 37. | $\Sigma y$ |
| | | RCL n 6 STR n 3 | 465. | $\Sigma y^2$ |
| | | RCL n 9 × = | 5.7 | $\sigma_x{}^2$ |
| | | STR n 6 | 5.7 | |
| | | σ | 2.081665999 | $\sigma_y$ |
| | | × = | 4.333333333 | $\sigma_y{}^2$ |
| | | STR n ÷ 6 | 4.333333333 | F in register 6 |

*Continued*

| Set | Enter | Depress | Read | Comment |
|---|---|---|---|---|
| | 4 | STR n, 1 | 4. | $n_x - 1$ ($df_x$) |
| | 2 | STR n, 2 | 2. | $n_y - 1$ ($df_y$) |
| F | | RCL n, 6, II | 0.474989227 | Rejection level |
| t | | RCL n, 0, CHG SIGN, II | 0.079724101 | t-ind |
| | 6 | = | 0.060950739 | Probability that t will not be exceeded |

## Poisson Distribution

$$P(y) = \frac{e^{-np}(np)^y}{y!}$$

Solve for P (y) with y = 6; y = 7; y = 8
n = 1500
p = 0.0023

| Set | Enter | Depress | Read | Comment |
|---|---|---|---|---|
| | 1500 | × | 1,500. | |
| | .0023 | =, STR n, 0 | 3.45 | np |
| | | CHG SIGN, $e^x$, STR n, 4 | 0.031745636 | $e^{-np}$ |
| | | RCL n, 0, $a^x$ | 3.45 | |
| n! | 6 | =, STR n, 1 | 1,686.221298 | $(np)^6$ |
| | 7 | =, STR n, 2 | 5,817.463479 | $(np)^7$ |
| | 8 | =, STR n, 3 | 20,070.249 | $(np)^8$ |
| | 6 | II, STR n, ÷, 1 | 720. | 6! |
| | 7 | II, STR n, ÷, 2 | 5,040. | 7! |
| | 8 | II, STR n, ÷, 3 | 40,320. | 8! |
| | | RCL n, 4, ×, RCL n, 1, = | 0.074347456 | P (6) |
| | | RCL n, 2, = | 0.036642675 | P (7) |
| | | RCL n, 3, = | 0.015802153 | P (8) |

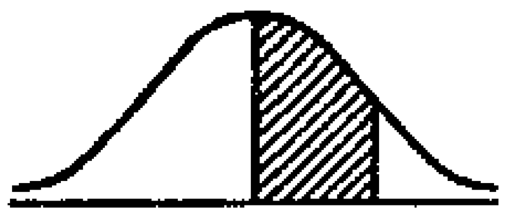
## Chi Square

Find the Chi-square value for following data and the probability that this value will not be exceeded.
Total frequency, N = 65.

| SAMPLE | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Observed Frequency ($f_o$) | 10 | 16 | 14 | 25 |
| Expected Frequency ($f_e$) | 8 | 19 | 17 | 21 |

$$\chi^2 = \Sigma \frac{(f_o - f_e)^2}{f_e} = \Sigma\left(\frac{f_o^{\,2}}{f_e}\right) - N$$

| Set | Enter | Depress | Read | Comment |
|---|---|---|---|---|
| X ⊓ XY; CLR 0-6 | | I | | Clear registers 0-6 |
| | 10 | × ÷ | 100. | $f_o^{\,2}$ |
| | 8 | = Σ | 12.5 | $\Sigma \frac{f_o^{\,2}}{f_e}$ |
| | 16 | × ÷ | 256. | |
| | 19 | = Σ | 13.47368421 | |
| | 14 | × ÷ | 196. | |
| | 17 | = Σ | 11.52941176 | |
| | 25 | × ÷ | 625. | |
| | 21 | = Σ | 29.76190476 | |
| | | RCL n 2 − | 67.26500074 | |
| $x^2$ | 65 | = II | 2.265000737 | $\chi^2$ |
| | 3 (df) | = | 0.480741026 | Probability that $\chi^2$ will not be exceeded |



## TABLE OF AREAS OF THE NORMAL CURVE*

| $(Y - \mu)/\sigma = Z$ | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .0000 | .0040 | .0080 | .0120 | .0160 | .0199 | .0239 | .0279 | .0319 | .0359 |
| 0.1 | .0398 | .0438 | .0478 | .0517 | .0557 | .0596 | .0636 | .0675 | .0714 | .0753 |
| 0.2 | .0793 | .0832 | .0871 | .0910 | .0948 | .0987 | .1026 | .1064 | .1103 | .1141 |
| 0.3 | .1179 | .1217 | .1255 | .1293 | .1331 | .1368 | .1406 | .1443 | .1480 | .1517 |
| 0.4 | .1554 | .1591 | .1628 | .1664 | .1700 | .1736 | .1772 | .1808 | .1844 | .1879 |
| 0.5 | .1915 | .1950 | .1985 | .2019 | .2054 | .2088 | .2123 | .2157 | .2190 | .2224 |
| 0.6 | .2257 | .2291 | .2324 | .2357 | .2389 | .2422 | .2454 | .2486 | .2517 | .2549 |
| 0.7 | .2580 | .2611 | .2642 | .2673 | .2704 | .2734 | .2764 | .2794 | .2823 | .2852 |
| 0.8 | .2881 | .2910 | .2939 | .2967 | .2995 | .3023 | .3051 | .3078 | .3106 | .3233 |
| 0.9 | .3159 | .3186 | .3212 | .3238 | .3264 | .3289 | .3315 | .3340 | .3365 | .3389 |
| 1.0 | .3413 | .3438 | .3461 | .3485 | .3508 | .3531 | .3554 | .3577 | .3599 | .3621 |
| 1.1 | .3643 | .3665 | .3686 | .3708 | .3729 | .3749 | .3770 | .3790 | .3810 | .3830 |
| 1.2 | .3849 | .3869 | .3888 | .3907 | .3925 | .3944 | .3962 | .3980 | .3997 | .4015 |
| 1.3 | .4032 | .4049 | .4066 | .4082 | .4099 | .4115 | .4131 | .4147 | .4162 | .4177 |
| 1.4 | .4192 | .4207 | .4222 | .4236 | .4251 | .4265 | .4279 | .4292 | .4306 | .4319 |
| 1.5 | .4332 | .4345 | .4357 | .4370 | .4382 | .4394 | .4406 | .4418 | .4429 | .4441 |
| 1.6 | .4452 | .4463 | .4474 | .4484 | .4495 | .4505 | .4515 | .4525 | .4535 | .4545 |
| 1.7 | .4554 | .4564 | .4573 | .4582 | .4591 | .4599 | .4608 | .4616 | .4625 | .4633 |
| 1.8 | .4641 | .4649 | .4656 | .4664 | .4671 | .4678 | .4686 | .4693 | .4699 | .4706 |
| 1.9 | .4713 | .4719 | .4726 | .4732 | .4738 | .4744 | .4750 | .4758 | .4761 | .4767 |
| 2.0 | .4772 | .4778 | .4783 | .4788 | .4793 | .4798 | .4803 | .4808 | .4812 | .4817 |
| 2.1 | .4821 | .4826 | .4830 | .4834 | .4838 | .4842 | .4846 | .4850 | .4854 | .4857 |
| 2.2 | .4861 | .4864 | .4868 | .4871 | .4875 | .4878 | .4881 | .4884 | .4887 | .4890 |
| 2.3 | .4893 | .4896 | .4898 | .4901 | .4904 | .4906 | .4909 | .4911 | .4913 | .4916 |
| 2.4 | .4918 | .4920 | .4922 | .4925 | .4927 | .4929 | .4931 | .4932 | .4934 | .4936 |
| 2.5 | .4938 | .4940 | .4941 | .4943 | .4945 | .4946 | .4948 | .4949 | .4951 | .4952 |
| 2.6 | .4953 | .4955 | .4956 | .4957 | .4959 | .4960 | .4961 | .4962 | .4963 | .4964 |
| 2.7 | .4965 | .4966 | .4967 | .4968 | .4969 | .4970 | .4971 | .4972 | .4973 | .4974 |
| 2.8 | .4974 | .4975 | .4976 | .4977 | .4977 | .4978 | .4979 | .4979 | .4980 | .4981 |
| 2.9 | .4981 | .4982 | .4982 | .4983 | .4984 | .4984 | .4985 | .4985 | .4986 | .4986 |
| 3.0 | .49865 | .4987 | .4987 | .4988 | .4989 | .4988 | .4989 | .4989 | .4989 | .4990 |

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