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Models

SR6140R, SR6120R
SR9140D, SR9120D
SR990D

Scientific Electronic Calculators

Owner's Manual

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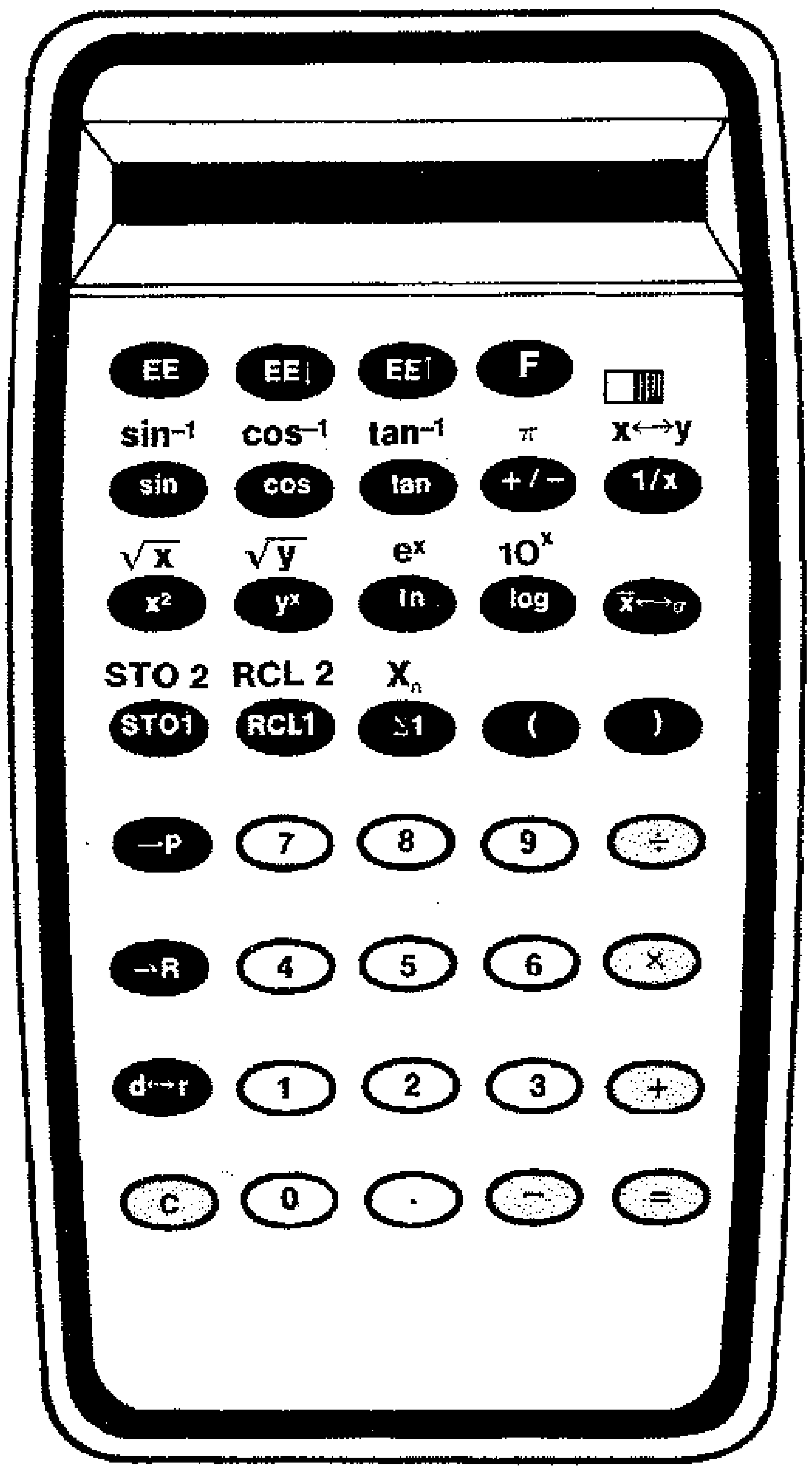
KEYBOARD



KEY INDEX

This index permits quick page location of the description and/or the first use of each function key.

INTRODUCTION

Thank you for selecting our new scientific calculator. We prefer to call it a mini-computer because of its ability to handle so extensive a range of complex assignments across a broad spectrum of basic and advanced mathematics.

It represents the finest achievement in solid state large scale integrated/metal oxide silicon technology. Its ten digit mantissa with its two digit exponent—able to handle values as small as 1.0×10^{-99} up to $9.999999999 \times 10^{99}$—affords far greater precision than is known to most of the physical constants in the universe.

Nonetheless, this mini-computer may also be regarded as simply a high-speed numeric answer machine. Its commonsense logic is the key to your mastery of it. You are able to enter basic assignments just as you would write them down on paper. For example, 4 x 5 = , is entered just as you see it. Higher math arguments are accomplished on your mini-computer by again entering examples as they are commonly written. Thus, the Log of 9- the Log of 4 is indexed: 9 Log-4 Log =.

This emphasis on academic principles is a consistent theme which runs throughout the logic of your new mini-computer.

Students will appreciate the fact that most math concepts have been programmed into the logic system. Among these basic tenets are such principles as any number raised to the zero power equals one; and zero raised to any power (except zero) equals zero. As can be seen, results will be precisely displayed for immediate comprehension.

Professionals will enjoy the added features of the machine such as the EE↑ and EE↓ keys which enable the automatic integer increase and decrease of an exponent.

In short, our mini-computer was designed by professionals for professionals and students alike. It has been developed as an easy-to-understand, easy-to-operate machine. Please read through the pages of this manual carefully. Become familiar with the keyboard and its characteristics. Work through the examples. They have been designed to give you a thorough understanding of all functions. Proficiency is gained by practice. Once you discover how easy your mini-computer is to operate, it will become an essential, enjoyable aid to you in every area of computation.

A special note concerning display capacity and machine logic.

This book has been prepared to illustrate the operation of a 14-digit machine.

In the event you have selected a machine with a 12- or 9-digit capacity, you are of course restricted to an entry limited by the number of digits in the mantissa and results will be truncated in accordance with the capacity of the display. This in no way alters the accuracy of your machine as the extra digits are retained within the unit's logic for continued computation. Thus, you can work all of the problems in this manual.

The treatment of numbers between +1 and −1 differs among models. In all instances both entry and result are accurate. However, some models will express these values in scientific notation.

	Enter:	Read:
Example A.	.002 X	2. −03
Example B.	.002 X	0.002

Both results are identical.

NUMERICAL ENTRY

0 through 9 • +/− EE

sample display	Sign of Mantissa	Mantissa	Sign of Exponent	Exponent
(14 digits):	−	0.123456789		90
(12 digits):	−	102.34578	−	99
(9 digits):	−	123.45	−	99

- **sign mantissa:** − or + , blank on display implies a positive number
- **mantissa:** 10 digit maximum in 14-digit display

  8 digit maximum in 12-digit display.

  5-digit maximum in 9-digit display.

Special Case: A result between 1 and −1 which has an exponent −01 is displayed in floating notation with a leading zero. This affects the display only. The logic of the calculator realizes the true 10-digit result and the ten digit accuracy is retained in the machine.

Enter:	**See Displayed:**
2 ÷ 3 =	0.666666666

Subsequent chain calculations will be computed using the true result retained internally in scientific notation:

6.666666666 −01

- **sign of exponent:** − or +, blank implies positive
- **exponent field:** two digits maximum

Entry: A number (the mantissa) is entered just as written using the keys **0 through 9.** The sign of the mantissa can be entered at any time during a numerical entry by pressing the change sign key **+/−** . The sign of the exponent can be changed by pressing the change sign key after the **EE** key (enter exponent key) has been pressed. The exponent field is blank until **EE** is entered.

C

The clear entry/clear key. Pressing the **C** during or immediately after a numerical entry will clear the display. Only prior entries are retained intact. Pressing the **C** key in all other cases clears your calculator; Memories are not cleared.

Enter:

2 **+** 3 **C** (Clear Entry) 4 **=** 6 **C** (Clear All)

In the above example, we wished to add **2** and **4** but entered **3** by mistake. Pressing **C** and entering **4** , corrects the error and allows further computation. The final **C** clears the calculator.

FOUR FUNCTION ARITHMETIC

+ **−** **×** **÷**

Example:

Enter:	Read:	Explanation:
3 **+/−** **×**	− 3.	Enter −3 and multiply
1.2 **EE** **+/−** 2	1.2 − 02	Enter 1.2×10^{-2}
=	− 0.036	Perform multiplication and display result

CHAIN CALCULATIONS

Example:

Calculate $\frac{3 \times 4}{5} \div .3$

Enter:	Read:	Explanation:
3 **×**	3.	Enter 3 and multiply
4	4.	Enter 4
÷	12.	The multiplication 3 × 4 is performed, the result, 12, is displayed and divide is entered.
5	5.	Enter 5

Enter:	Read:	Explanation:
÷	2.4	The result of the division 12 ÷ 5 is displayed and divide is entered
.3	0.3	Enter .3
=	8.	The result of $\frac{3 \times 4}{5} \div .3$ which is 8 in display

CORRECTING OPERATIONS

Example: Calculate 3 × 4

Enter:	Read:	Explanation:
3 +	3.	Enter 3. We wish to multiply but entered + by mistake.
×	3.	Enter the correct function key
4	4.	Now enter 4
=	12.	The result of 3 × 4 is displayed

In this manner any of the "four function" keys (+ − × ÷) can be over written by another; the final entry will be executed. For example:

Enter:	Read:	Explanation:
3 × +		
÷ − 4 =	− 1	The last function pressed, (−) is executed.

Use of the F Function Key.

Your mini-computer has 39 keys, one of which is a special function key marked "F." The application of this key enables you to increase the performance range of your machine by releasing twelve additional operations.

Twelve of the 39 keys are inscribed with upper case functions. If any one of these keys is pressed the lower case function is executed. However, if the F key is indexed immediately prior to pressing one of the "double function" keys, the upper case function is performed.

Example:

Enter:	Read:	Explanation:
a. 144	144.	Enter data.
X^2	20736.	Square 144.
b. 144	144.	Enter data.
F $\sqrt{X}$	12.	Obtain square root of 144.

USING THE MEMORY

Store: **STO 1** **STO 2**

The store keys refer to the two memory registers which store data for future use. When **STO 1** is pressed, the value currently on the display will be copied into Memory Register 1. Similarly, when the **F** key is entered as a prefix to the Memory Key, the **STO 2** register is activated and the displayed data is copied into Memory Register 2. Any data stored in the register prior to pressing the respective **STO** key will be lost. This is referred to as "writing over."

Recall: **RCL 1** and **RCL 2**

These keys are used to recall data stored in their associated memory registers. The value stored in memory is copied onto the display; the value on display prior to recall is unaltered. To recall data in **STO 2**, Press key sequence **F** **RCL 2**.

Example:

Enter:	Read:	Explanation:
5	5.	Enter 5
STO 1	5.	Copies 5 into memory register 1
6	6.	Enter 6
F STO 2	6.	Copies 6 into memory register 2
RCL 1	5.	The content of Memory 1 (5) is copied onto the display. Five remains in Memory 1.
F RCL 2	6.	The content of Memory 2 (6) is copied onto the display. Six is retained in Memory 2.

Clear:

An individual memory register can be cleared by entering the key sequences:

C **STO 1** Clears memory register 1.

F **C** **STO 2** Clears memory register 2.

The **C** key need not be entered if 0. is on the display. However, you must still press the appropriate storage entry keys to replace the existing data with a zero value. Both memory registers are cleared at power on.

CHAIN CALCULATIONS USING MEMORY

Examples:

Enter:	Read:
① 3 × 5 × 4 ÷ 6 = STO 1	10.

The result of the calculation (10) is displayed and stored in Memory 1 for future recall.

Enter:	Read:
② 3 + 5 + RCL 1 =	18.

The value in Memory 1 (10) is added to 8 and the result is displayed. Memory 1 is unaffected.

Enter:	Read:
③ 3 × 5 × 4 ÷ 6 = F STO 2	10.

The result of the calculation is displayed and stored in Memory 2 for future recall.

Enter:	Read:
① 3 × 4 ÷ F RCL 2 =	1.2

The value stored in Memory 2 (10) is included in the calculation and the result is displayed. Memory 2 is unaltered.

CHAINING WITH PARENTHESIS KEYS

(**)** The open and close parenthesis keys provide another level of priority in arithmetic calculations.

For example let's solve the equation:
$y = 3Z^3$ where $Z = 4e^{-t} + e^t$ and $t = 3$

Enter:	Read:
3 ×	3.
Enter the "Z" multiplier 3	
(	3.
Initiate second level of calculation	
4 ×	4.
Enter 4 and multiply	
3 +/− F eˣ +	0.199148273
Calculate & display $4e^{-3}$ and add	
3 F eˣ	20.08553692
Calculate & display e^3	
)	20.2846852
Calculate $Z = 4e^{-3} + e^3$ and end second level of calculation	
yˣ 3	3.
Enter Z as the base 3 or the power	
=	25039.52414
Calculate $3Z^3$	

Example:

Calculate the product of two sums:

$(a+b) \times (c+d)$ say $(2+3) \times (4+5)$

Enter:	Read:	Explanation:
2 +	2.	2 add entered
3 ×	5.	2 + 3 calculated and displayed × entered
(	5.	Second level of calculation initiated
4 +	4.	4 add entered
5	5.	5 entered
)	9.	4 added to 5. Second level calculation terminated
=	45.	(2+3) multiplied by (4+5)

EXCHANGE REGISTER KEY

x↔y The exchange key reverses the order of the operands and is used with the four function keys (+ − × ÷) as well as to enter and display calculations for the functions →P , →R and $\bar{x} \longleftrightarrow \sigma$

RECIPROCAL KEY

1/x The reciprocal or inverse function key computes the inverse of a number on the display and instantly displays the result.

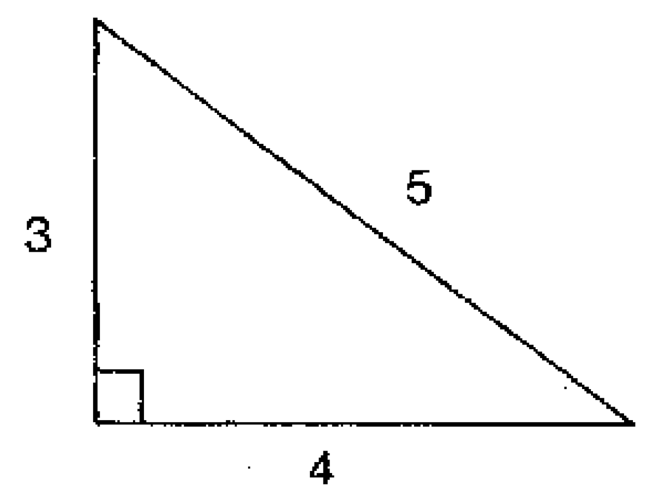
POWER AND ROOT KEYS

x^2 The Square key raises the number currently on display to the second power.

$\sqrt{x}$ The Square Root key takes the square root of the number currently on display.

Examples :

① Calculate the hypotenuse of a triangle whose sides measure 3 and 4



Enter:	Read:	Explanation:
3 x^2 +	9.	Calculate 3^2 and add
4 x^2	16.	Calculate 4^2
=	25.	Calculate $(3^2 + 4^2)$
F $\sqrt{x}$	5.	The hypotenuse measures 5

y^x $\sqrt[x]{y}$ With the power key, a number raised to any power (or root) can be calculated. The base is entered first, then the power key, and finally the power (or root) to which the base is to be raised. Powers are calculated using the formula $y^x = e^{(x \ln y)}$, $\sqrt[x]{y} = e^{\left(\frac{\ln y}{x}\right)}$. Therefore, negative bases are not permitted. Any attempt to raise a negative base to a power will result in an error condition. In addition to performing all commonly encountered powers and roots accurately and quickly, your calculator will correctly perform these calculations:
$0^0 = 1$, $x^0 = 1$, $0^x = 0$ for $x \neq 0$.

⑨ **Chain calculation involving y^x key**

Calculate $3x^5 - x^3 + 4$ for $x = 4$

Enter:	Read:	Explanation:
3 ×	3.	Enter 3 and multiply
4 y^x	4.	Enter 4 as the base
5	5.	Enter 5 as the power
−	3072.	Calculate and display $3(4)^5$ and enter subtract
4 y^x	4.	Enter 4, the base
3	3.	Enter 3, the power
+	3008.	Calculate and display $3(4)^5 - (4)^3$ enter add
4 =	3012.	$3(4)^5 - (4)^3 + 4 = 3012.$

⑩ **Binary to decimal conversion:**

Convert the binary number 11011 to decimal. 11011 in base 2 is equal to $2^4 + 2^3 + 2^1 + 2^0$ in decimal.

Enter:	Read:	Explanation:
2 y^x	2.	Enter 2, the base
0 +	1.	Calculate & display 2^0 and add
2 y^x	2.	Enter 2, the base
1 +	3.	Calculate & display $2^0 + 2^1$ Enter and add
2 y^x	2.	Enter 2, the base
3 +	11.	Calculate and display 2 + 2 + 2 and add
2 y^x		
4 =	27.	Terminate calculation & display result

11011 base 2 = 27 base 10

What are the monthly payments on a $20,000 mortgage at 9% annually extending over 20 years?

formula: $PMT = \frac{PV\,I}{1 - (1 + I)^{-n}}$

Where PV is the Principal (present value) of the mortgage
I is the monthly interest expressed as a decimal
n is the number of months
PMT is the monthly payment

Enter:	Read:
.09 ÷ 12 +	0.0075
Calculate the monthly interest (9% for 12 months)	
1 = yˣ	1.0075
Calculate (1 + I) and enter it as the base	
240 +/−	− 240.
Enter the number of months, change the sign, calculate $(1 + I)^{-n}$ and subtract 1	
= +/− + 1 = STO 1	0.833587156
Store $1 - (1 + I)^{-n}$ in memory	

Enter:	Read:
.09 ÷ 12 ×	0.0075
Calculate the monthly interest and multiply	
20000 ÷	150.
Calculate PV Enter divide	
RCL 1 =	179.945191
The dollar amount necessary to amortize a $20,000 mortgage in 20 years at 9% annual interest	

⑤ **Hypotenuse Calculations**

Given a right triangle, three meters on one side and four on the other, find the hypotenuse. The equation is:

$R = \sqrt{A^2 + B^2}$ A = side 1 B = side 2

Find R, if A = 3 and B = 4

Enter:	Read:	Explanation:
3 yˣ	3.	Enter 3, the base
2 +	9.	Calculate & display 3^2

Enter:	Read:	Explanation:
4 y^x	4.	Enter 4, the base
2 =	25.	Calculate and display $3^2 + 4^2$
F $\sqrt[x]{y}$	25.	Enter 25 as the base
2 =	5.	Calculate and display the second root of 25.

See Example ⓘ for alternate solution.

Example:

ⓖ **Find the radius of a sphere whose volume is 2144 cubic meters.**

Equation: $R = \sqrt[3]{\frac{3V}{4\pi}}$ R = radius V = Volume

Enter:	Read:	Explanation:
2144 ×	2144.	Enter the Volume - multiply
3 ÷	6432.	By 3 divide
4 ÷	1608.	By 4 divide
F π =	511.842297	By π

Enter:	Read:	Explanation:
F $\sqrt[x]{y}$	511.842297	Enter $\frac{3V}{4\pi}$ as the base
3 =	7.999178546	Calculate the cubic root of $\frac{3V}{4\pi}$ and display result

The sphere has a radius of approximately 8 meters.

TRANSCENDENTAL FUNCTIONS

Your scientific calculator will perform common and natural (Naperian) logarithmic and inverse logarithmic functions. It also calculates the three trigonometric functions and their inverses. Each of these keys operates on the value currently on display.

Logarithmic Functions

log Calculates the common logarithm ($\log_{10}$) of x.

10^x Calculates the common antilogarithm of x.

ln Calculates the natural logarithm ($\log_e$) of x.

e^x Calculates the natural antilogarithm of x.

Examples:

① Natural logarithm ln and inverse natural logarithm function, e^x
Calculates $e^{\ln 2 + \ln 3}$

Enter:	Read:	Explanation:
2 **ln** +	0.69314718	Calculate ln 2 and enter +
3 **ln**	1.098612289	Calculate ln 3
=	1.791759469	Display result of $\ln^2 + \ln^3$
F e^x	6.	Calculate the inverse function.

The above calculation demonstrates the equation ln (a) + ln (b) = ln (ab)
To calculate the hyperbolic arc tan of .5:

② Equation: arctanh X = ½ ln $\left(\frac{1 + x}{1 - x}\right)$

Enter:	Read:	Explanation:
1 − .5 = **STO 1**	0.5	Store (1 − .5) in Memory 1
1 + .5 = ÷	1.5	Calculate (1 + .5), enter divide
RCL 1 =	3.	Calculate (1 + .5)
ln	1.098612289	Calculate ln [(1 + .5)/(1 − .5)]
÷ 2 =	0.549306144	Calculate ln / 2 $\left[\frac{(1+.5)}{(1-.5)}\right]$ arc tan =

③ Calculate the hyperbolic sine of .5

Equation: $\sinh x = \frac{e^x - e^{-x}}{2}$

Enter:	Read:	Explanation:
.5 **F** e^x −	1.648721271	Calculate and display the exponential function of .5, $e^{.5}$ and enter −
.5 +/− **F** e^x	0.606530659	Calculate and display the exponential of −.5
÷	1.042190611	Perform subtraction, display result, and enter ÷
2 =	0.521095305	Divide by 2 and display the result, the sinh of .5

Trigonometric Functions

sin Calculates sine of x.

F **sin⁻¹** Calculates inverse sine of x.

cos Calculates cosine of x.

F **cos⁻¹** Calculates inverse cosine of x.

tan Calculates tangent of x.

F **tan⁻¹** Calculates inverse tangent of x.

Your calculator will find the sine, cosine, tangent, arc sine, arc cosine and arc tangent of any number on display in either degrees or radians. The calculator is in degree mode when turned on. Pressing the **d/r** key shifts your calculator to radian mode, lights a decimal point in the exponent field, and converts the value on display from degrees to radians. Pressing **d/r** again shifts the calculator back to degree mode and converts the display in degrees.

Input range for sine, cosine and tangent is ± *0-360°*

Example: Degree Mode

Enter:	**Read:**
30	30.
sin	0.5
F **sin⁻¹**	30

Enter:	**Read:**
120	120
cos	– 0.5
F **cos⁻¹**	120
45	45.
tan	1.
F **tan⁻¹**	45

Example: Radian Mode

Enter:	**Read:**	**Explanation:**
C **d/r** **F** π		
÷ 6 =	.523598775 •	
sin	0.5 •	
F **sin⁻¹**	0.523598775 • (↑ Radian Indicator)	enter $\frac{\pi}{6}$ radian

Conversion to radian

①

Enter:	Read:	Explanation:
C	0.	
120	120.	
d/r	2.094395102 •	120° converted to $\frac{2\pi}{3}$ rad. Radian mode initiated
cos	– 0.5 •	
F cos⁻¹	2.094395102 •	
d/r	120.	Convert back to degrees. Initial degree mode

②

Enter:	Read:	Explanation:
45	45.	
d/r	0.785398163 •	45° converted to $\frac{\pi}{4}$ rad. Radian mode initiated
tan	1. •	
F tan⁻¹	0.785398163 •	
d/r	45.	Convert back to degrees and initiate degree mode

POLAR/RECTANGULAR COORDINATE CONVERSION

Polar/rectangular coordinate conversion requires two input values and has two output values. After entering the first value, press **F** **x⟷y** , then enter the second value. They operate on both degrees or radian mode. Note that polar/rectangular coordinate calculations cannot be chained.

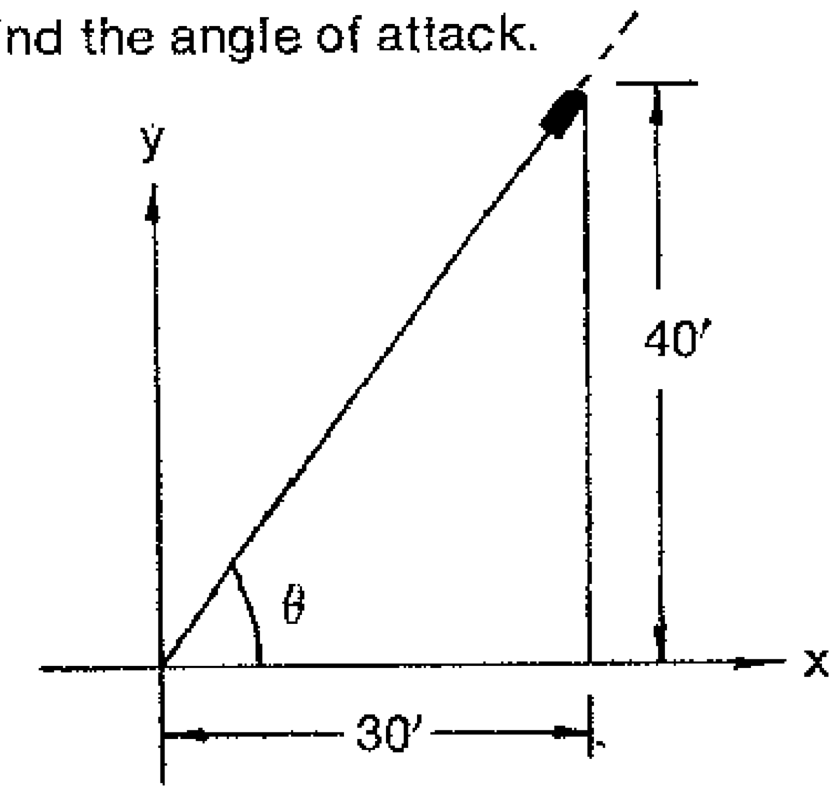
→P This key converts rectangular coordinates, x and y to polar form. The resulting magnitude is displayed first. Pressing **F** **x⟷y** displays the angle.

Formulas: $R = \sqrt{x^2+y^2}$
$\theta = \tan^{-1}(y/x)$

The x value is entered first.

Example:

A projectile is assumed to have a straight path at the first few seconds of flight. Find the distance traveled if it has a horizontal traverse of 30 feet and a vertical traverse of 40 feet. Also, find the angle of attack.



Enter:	Read:	Explanation:
30	30.	Horizontal distance
F x←→y 40	40.	Vertical distance
→P	50.	Distance traveled
F x←→y	53.13010235	Angle of attack

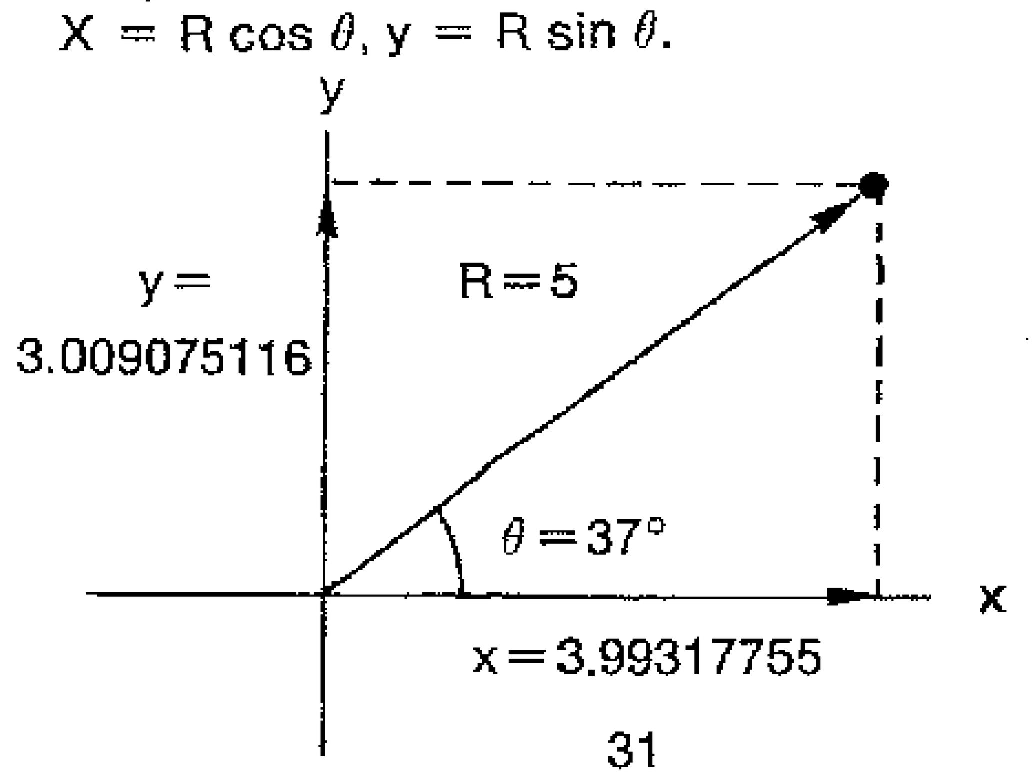
→R This key converts a polar pair value to rectangular coordinates. The resulting x coordinate is displayed first. Pressing x←→y displays the y coordinate.

Formulas: $x = R \cos \theta$
$y = R \sin \theta$

R is entered first.

Example:

A result in polar coordinates of a radius of 5 at an angle of 37° is to be converted to rectangular coordinates. The transformation is $X = R \cos \theta$, $y = R \sin \theta$.



Enter:	Read:	Explanation:
5	5.	
F x←→y	0.	
37	37.	
→R	3.99317755	The "x" coordinate
F x←→y	3.009075116	The "y" coordinate

A converted polar/rectangular coordinate value can be restored as shown by the following example:

Example:

Convert the pair of rectangular coordinates x=3, y=4 to Polar coordinates

Enter:	Read:	Explanation:
3 F x←→y	0.	3 has been entered
4	4.	
→P	5.	The radius is 5
F x←→y	53.13010235	θ = 53.13010235

We can now convert back. Let's first convert this angle to radians.

Enter:	Read:	Explanation:
d/r	0.927295218 •	Radian mode.
→R	3. •	x value displayed
F x⟷y	4. •	y value displayed
F x⟷y	3. •	x recovered

USE OF THE EXPONENT KEYS

EE Enables entry of exponent values.

EE↑ Increases the exponent value by one with a corresponding shift of the decimal point in the mantissa.

EE↓ Decreases the exponent value by one with a corresponding shift of the decimal point in the mantissa.

Examples:

Enter:	Read:	Explanation:
5.5 EE 46	5.5 46	
EE↑	0.55 47	Increase exponent Shift decimal left
EE↑	0.055 48	Shift decimal left
EE↑	0.0055 49	Shift decimal left
EE↓	0.055 48	Decrease exponent
EE↓	0.55 47	Shift decimal right
EE↓	5.5 46	Shift decimal right

Example: What is the time constant of an RC circuit with a 4 picofarad capacitor and a resistance of 7.5 Megohms? $\tau = RC$

C = .4 pf R = 7.5 MegΩ

Enter:	Read:	Explanation:
4 EE 12 +/−	4. −12	
× 7.5 EE 6	7.5 06	
=	0.00003	time constant
EE↓ EE↓ EE↓	0.03 −03	time constant is 0.03 ms
EE↓ EE↓ EE↓	30. −06	time constant is 30. μs

MEAN AND STANDARD DEVIATION CALCULATIONS

X_n / **$\bar{x} \leftrightarrow \sigma$** Mean and Standard deviation can be calculated with these two keys. The series of values to be averaged is entered by the **X_n** key. The mean standard deviation is calculated when the **$\bar{x} \leftrightarrow \sigma$** key is pressed. The mean is displayed first and the standard deviation can be recovered by pressing the exchange key **x↔y** . The standard deviation provides a measure of the distribution of values about the mean. The second memory register is used for accumulating and must be cleared before the mean calculation is begun.

The **X_n** key has an added advantage. It may be used as a summation Σ key for accumulation in the STO 2 memory FOR ALL EXAMPLES EXCEPT STANDARD DEVIATION. During standard deviation problems the **X_n** key automatically occupies the STO 2 memory to plot distribution entries. (For a detailed explanation of memory accumulation refer to description of Σ1 key.)

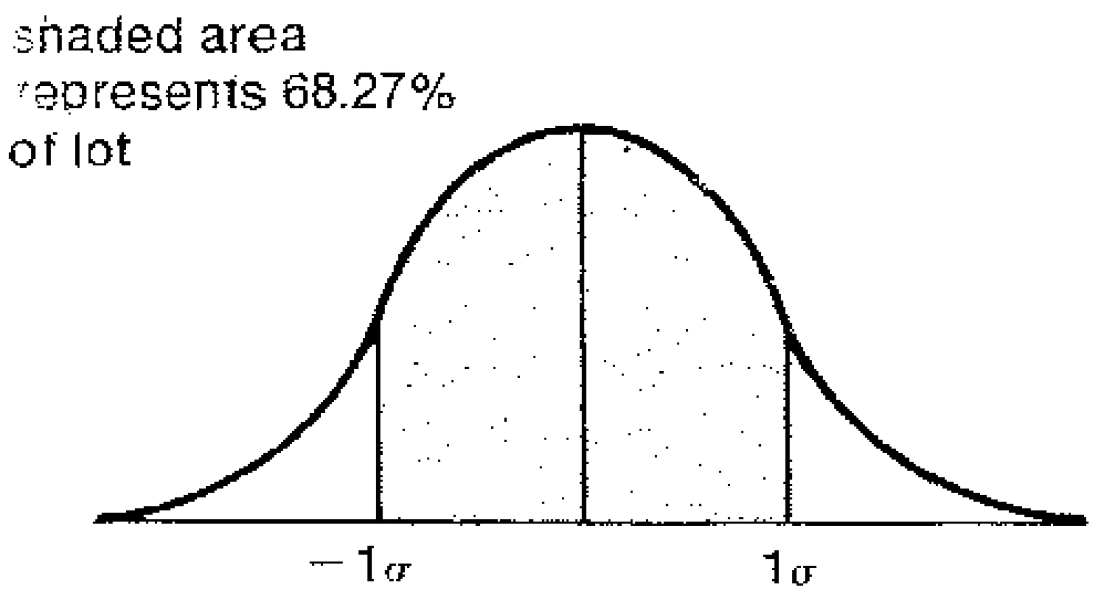
Example:

The following represents a portion of the inventory received by Company X.

Lot #	1	2	3	4	5	6	7
# of Parts	147	130	164	201	127	150	121

Based on this chart, what is the average number of parts per lot and how certain is this average?

Enter:	Read:	Explanation:
C F STO 2	0.	Clear Memory 2
147 F X_n	147.	Enter first # of parts
130 F X_n	130.	Enter second
164 F X_n	164.	Enter third
201 F X_n	201.	Enter fourth
127 F X_n	127.	Enter fifth
150 F X_n	150.	Enter sixth
121 F X_n	121.	Enter seventh
$\bar{x} \leftrightarrow \sigma$	148.5714286	The average # of parts per lot
F x↔y	27.57327899	The standard deviation



$-1\sigma = 120.9981485$ $+1\sigma = 176.1447076$

With 68.27% certainty, Company X can assume that they will receive between 120.9981496 and 176.1447076 parts per lot on normal distribution.

STANDARD DEVIATION

$$\sigma^2 = \frac{\sum_1^n (x_i - \bar{x})^2}{n - 1} \qquad \text{with } \bar{x} = \frac{\sum_1^n x_i}{n}$$

$\bar{x}$ is the mean and σ measures how far apart from the mean are the extremes $\bar{x}$. σ gives an idea of the distribution spread of the sample.

Example:

You throw darts and note the points obtained on 8 throws: 21, 17, 13, 25, 9, 19, 6, 10. What is your average mark and your standard deviation?

Enter:	Read:	Explanation:
21	21	
F x_n	21	enter x_i
17	17	
F x_n	17	
⋮	⋮	
6	6	
F x_n	6	
10	10	
F x_n	10	

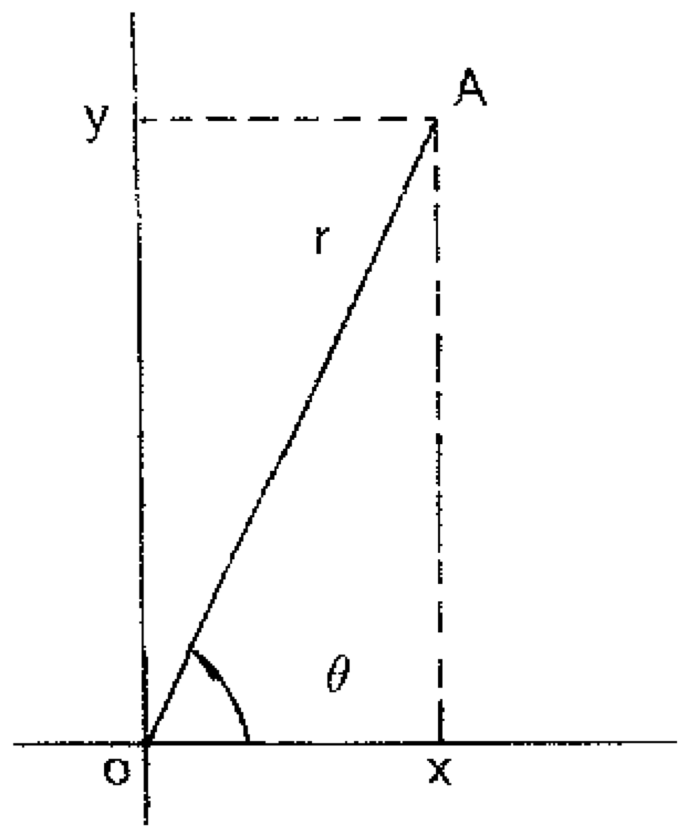
Now by pressing x←→y you will display the number of throws: 8. Now press x←→y again to get back in the standard deviation computing mode:

Enter:	Read:	Explanation:
$\bar{x}$←→σ	15	get x
F x←→y	6.568322247	get σ

Your average mark is 15 and you deviate from it by a 6.57 spread. Note that such spread does not measure the simple arithmetic deviation but the "normalized" one obtained by the difference of squares between x_i and x.

SPECIAL APPLICATIONS

POLAR/RECTANGULAR COORDINATES CONVERSION



A point "A" may be identified either by its rectangular coordinates x, y or its polar coordinates r, θ:

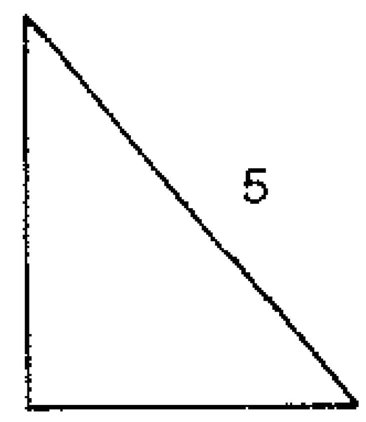
We have: $x^2 + y^2 = r^2$ and $x = r\cos\theta$, $y = r\sin\theta$. Your mini computer identifies the first entry as x or r, the second as y or θ. The second entry is separated from the first one by using the F x←→y (exchange) key.

Examples:

Enter:	Read:
3 (x) F x←→y	0.
4 (y)	4.
→P key (to Polar)	5.(r)
F x←→y	53.13010235 degrees(θ)

Now, your mini computer acts as if you had entered 5 (r) first and then θ : 53.13010235 second. Press: →R (to rectangular) read: 3 (x) press x-y and read: 4 (y).
Your minicomputer also calculates the hypotenuse of a rectangular triangle:

We discussed calculating the hypotenuse of a right triangle by using the "X" square and square root keys on page 21. The rectangular coordinate key offers a short cut:

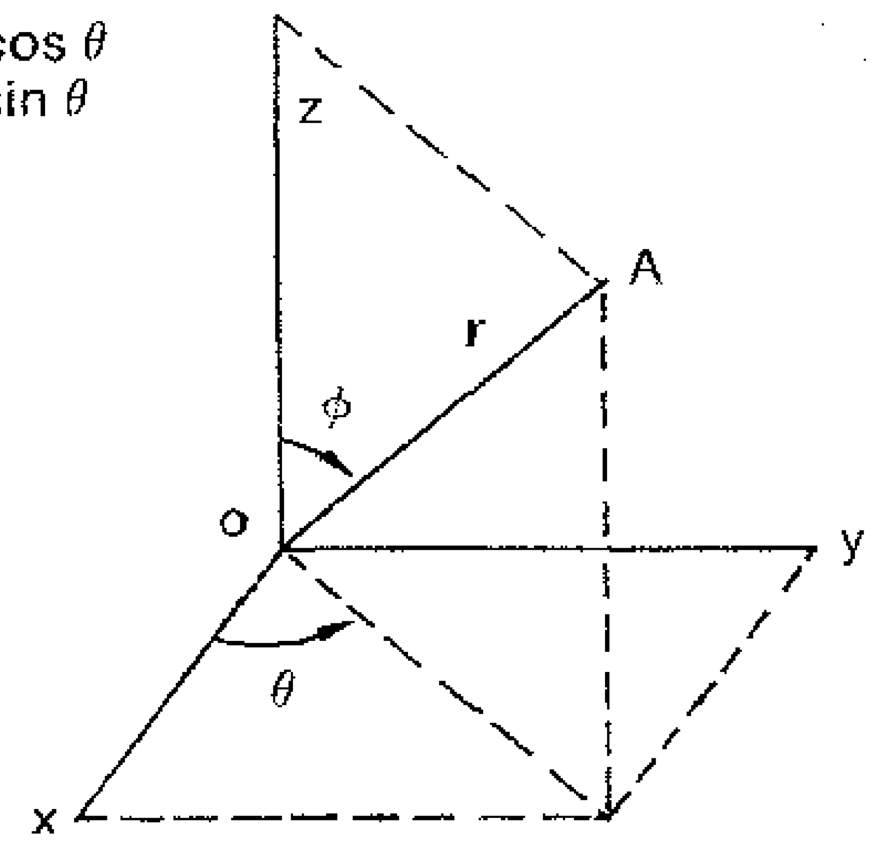


$5^2 = 4^2 + 3^2$

Enter:	Read:	Explanation:
3 + 4 →P	5	+ key entry may be replaced by exchange key. See example above.

SPHERICAL COORDINATES

$x = r \sin\phi \cos\theta$
$y = r \sin\phi \sin\theta$
$z = r \cos\phi$



Entering x and y will give θ and $r \sin\phi$
Entering $r \sin\phi$ and z will give y and r.

RECTANGULAR TO SPHERICAL CONVERSION

Enter as in following example:

Enter	Read:	Explanation:
3	3.	enter x
F x←→y	0.	allow for next entry
4	4.	enter y
→P	5.	get intermediate result $r \sin\phi$
F x←→y	53.13010235	get θ
7	7.	enter z
F x←→y	5.	recall intermediate result
→P	8.602325267	get r
F x←→y	35.53767779	get ϕ

SPHERICAL/RECTANGULAR CONVERSION

Enter:	Read:	Explanation:
8.6	8.6	enter r
F x←→y	8.602325267	allow for next entry
35.54	35.54	enter ϕ
→R	6.997905251	get z
53.13	53.13	enter θ
→R	2.999366402	get x
F x←→y	3.999140319	get y

ELECTRICAL ENGINEERING

Example:

Find the current I_D flowing through an MOS device operating in the saturation region

$$I_D = \mu \frac{\varepsilon_{OX} \cdot \varepsilon_O \cdot W}{t_{OX} \quad L} \times \frac{(V_G - V_T)^2}{2}$$

where μ = substrate mobility factor
ε_{OX} = oxide dielectric constant
ε_O = free space permittivity = 8.85×10^{-14} F/cm
t_{OX} = oxide thickness
W = device width
L = device length
V_G = gate/source voltage
V_T = threshold voltage

Example: μ = 190 cm^2/volt sec
ε_{OX} = 3.9
W = 2.0 mil
L = .3 mil
t_{OX} = 1100 Å = 1.1×10^{-5} cm
V_G = 8 V
V_T = 1 V

Enter:	Read;	Explanation:
190	190.	enter μ
×	190.	
3.9	3.9	enter ε_{OX}
×	741.	
8.85	8.85	
EE	8.85 −00	
+/−	8.85 −00	
14	8.85 −14	enter ε_O
×	6.55785 −11	
2	2.	
×	1.31157 −10	enter W
(	1.31157 −10	
8	8.	V_G
−	8.	
1	1.	

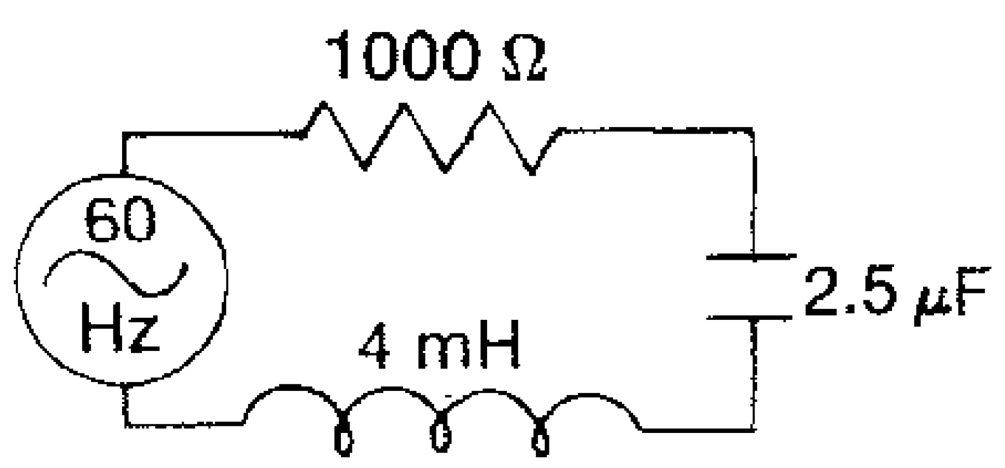
Enter:	Read:	Explanation:
)	7.	$(V_G - V_T)^2$
X^2	49.	
=	6.426693 −09	
÷	6.426693 −09	
(	6.426693 −09	
1.1	1.1	enter t_{OX}
EE	1.1 00	
5	1.1 05	
+/−	1.1 −05	
×	0.000011	
.3	.3	enter L
×	0.0000033	
2	2.	
)	0.0000066	V_T
=	9.737413636 −04	get I_D
EE EE	973.7413636 −06	twice to get result in micro amperes

ELECTRICAL IMPEDANCE

Using the **→P** key to compute expressions of the form $\sqrt{A^2 + B^2}$ in a variety of problems.

Example: Electronics

In the Resistance Inductance Capacitance (RLC) circuit below what is the:
a) Reactance of the inductor
b) Reactance of the capacitor
c) Impedance of the circuit
d) Phase angle



x_L = Reactance of the inductor = $2\pi fL$

x_C = Reactance of the capacitor = $\frac{1}{2\pi fC}$

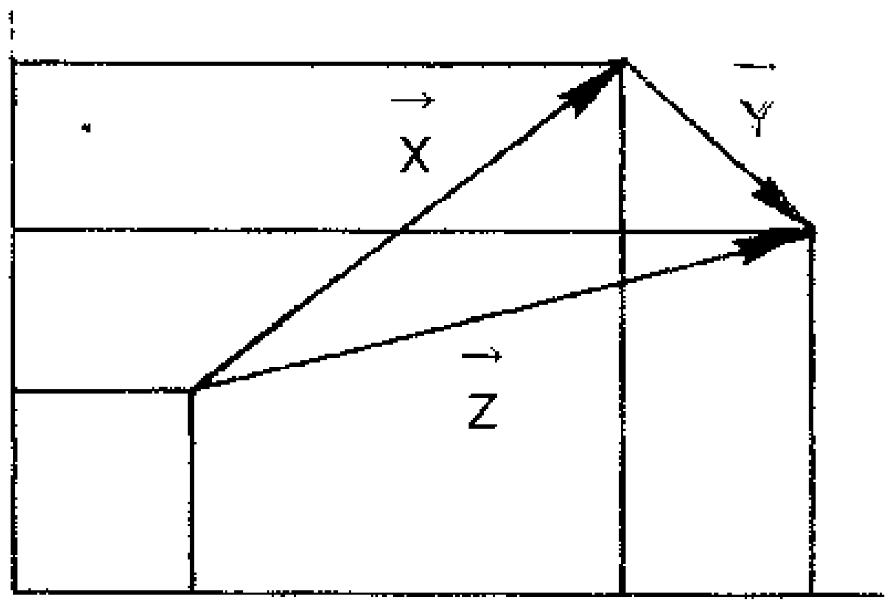
$Z = \sqrt{R^2 + (x_L - x_C)^2}$ = Impedance

$\phi = \text{Arctan}\left(\frac{x_L - x_C}{R}\right)$

Enter:	Read:	Explanation:
2	2.	
×	2.	
π	3.141592654	
×	6.283185307	
60	60.	Enter F in Hz
×	376.9911184	
2.5	2.5	
EE	2.5 00	
6	2.5 06	
+/−	2.5 − 06	Enter C in μF
=	9.424777961 − 04	
1/x	1061.032954	Get x_C
+/−	−1061.032954	
+	−1061.032954	
(	−1061.032954	
2	2.0	
×	2.0	
π	3.141592654	

Enter:	Read:	Explanation:
×	6.283185307	
60	60.	Enter F in H_z
×	376.9911184	
4	4.	
EE	4. 00	
3	4. 03	
+/−	4 - 03	Enter L in mH
)	1.507964474	Get x_L
=	− 1059.52499	Get $x_L - x_C$
F x←→y	0.	Allow for next entry
1000	1000	Enter R in Ohms
F x←→y	− 1059.52499	Position registers to compute right phase angle
→P	1456.912215	Get Z in Ohms
F x←→y	− 46.65551839	Get ϕ in degrees

VECTOR ADDITION



The vectors are represented in rectangular coordinates by:

$$x_z = x_x + x_y$$
$$y_z = y_x + y_y$$

and in polar coordinates by:

$$\vec{x} = R_x \angle \theta_x$$
$$\vec{y} = R_y \angle \theta_y$$
$$\vec{z} = R_z \angle \theta_z$$

With: $R_x^2 = X_x^2 + Y_x^2$

$R_y^2 = X_y^2 + Y_y^2$

$R_z^2 = X_z^2 + Y_z^2$

and: θ = Arc tan y/x for each vector.

Example: Add the two vectors $\vec{X} = 6 \angle 20°$ and $\vec{Y} = 4 \angle 30°$

Enter:	Read:	Explanation:
C	0.	
STO 1	0.	
F STO 2	0.	
6	6.	enter R_x

Enter:	Read:	Explanation:
F x←→y	0.	allow next entry
20	20.	enter θ_x
→R	5.638155725	get x_x
Σ1	5.638155725	store x_x
F x←→y	2.05212086	get y_x
F STO 2	2.05212086	store y_x
4	4.	enter R_y
F x←→y	5.638155725	allow next entry
30	30.	enter θ_y
→R	3.464101615	Get x_y
Σ1	3.464101615	add $x_y + x_x = x_z$
F RCL 2	2.05212086	recall y_x
F x←→y	2	get y_y
+	4.05212086	add $y_x + y_y = y_z$
RCL 1	9.10225734	recall $x_y + x_x$
F x←→y	4.05212086	position registers in right sequence
→P	9.963471892	get R_z
F x←→y	23.99755606	get θ_z (decimal degrees)

SUMMATION KEY

Σ1 The summation key, when pressed, adds the number on display to the value stored in Memory 1. Both, negative and positive numbers can be accumulated in Memory 1. It is good practice to clear Memory 1 before using the **Σ1** key with the key sequence

C **STO 1**

Example:

What is the total of
110, 120, 111, 142, 1310, 321?

Enter:	Read:	Explanation:
C STO 1	0.	Clear Memory 1
110 Σ1	110.	110. added to Mem. 1
120 Σ1	120.	120. added to Mem. 1
111 Σ1	111.	111. added to Mem. 1
142 Σ1	142.	142. added to Mem. 1
1310 Σ1	1310.	1310. added to Mem. 1
321 Σ1	321.	321. added to Mem. 1
RCL 1	2114.	Display the result of the summation

APPENDIX A

Error Condition

An error condition results when an improper operation is performed or when the result of an operation overflows or under flows the absolute range of the calculator.

When an error condition occurs the letter "E" is displayed.

Press the clear key to clear the error condition.

Improper Operation:

X ÷ Y	where Y = 0
Y^x	where y < 0
F $\sqrt[x]{y}$	where X < 0
F $\sqrt{x}$	where X < 0
1/x	where X = 0
$\bar{X} \longleftrightarrow \sigma$	where number of entries is 0
ln X	where X ≤ 0
log X	where X ≤ 0
F $\sin^{-1}$ X	where |X| >1
F $\cos^{-1}$ X	where |X| >1
X F X⟷Y Y →R	where X = 0

Overflow

Occurs when a computed result is greater than 9.999999999 x 10^{99}

Underflow

Occurs when a computed result is less than 1.0 x 10^{-99}

APPENDIX B

OPERATING ACCURACY

The precision of your calculator depends upon the operation being performed. Basic addition, subtraction, multiplication, division and reciprocal assignments have a maximum error of ± one count in the tenth or least significant digit.

While countless computations may be performed with complete accuracy, the accuracy limits of particular operations depend upon the input argument as shown below.

Function	Input Argument	Mantissa Error (Max.)
F $\sqrt{x}$		2 counts in D_{10}
ln x		1 count in D_{10}
log x		1 count in D_{10}
F e^x		3 counts in D_{10}
y^x		1 count in D_9
sin ϕ	$0° \leq \|\phi\| \leq 360°$ or $0 \leq \|\phi\| \leq 2\pi$	8 counts in D_{10}
cos ϕ	$0° \leq \|\phi\| \leq 360°$ or $0 \leq \|\phi\| \leq 2\pi$	8 counts in D_{10}
tan ϕ	$0 \leq \|\phi\| < 89°$ $89° \leq \|\phi\| \leq 89.95°$	4 counts in D_9 1 count in D_6
F $\sin^{-1}$ x	$10^{-10} \leq \|x\| \leq 1$	$E < 5 \times 10^{-8}$
F $\cos^{-1}$ x	$10^{-10} \leq \|x\| \leq 1$	$E < 5 \times 10^{-8}$
F $\tan^{-1}$ x		$E < 5 \times 10^{-8}$

Dn = Nth display digit assuming a left justified 10 digit result.

INTERNATIONAL SYSTEM OF UNITS (SI)
LETTER SYMBOLS FOR QUANTITIES & UNITS

ELECTRICAL ENGINEERING QUANTITIES

Quantity	Qty. Symbol	SI Unit	Unit Symbol	Identical Unit
charge	Q	coulomb	C	A•s
current	I	ampere	A	
voltage	$V, E \ldots U$	volt	V	W/A
electromotive force	V	volt	V	
potential difference	V, ϕ	volt	V	
resistance	R	ohm	Ω	V/A
conductance	G	siemens	S	A/V
reactance	X	ohm	Ω	V/A
susceptance	B	siemens	S	A/V
impedance	Z	ohm	Ω	V/A
admittance	Y	siemens	S	A/V
capacitance	C	farad	F	C/V
inductance	L	henry	H	Wb/A
energy, work	W	joule	J	N•m
power (active)	P	watt	W	J/s
power — apparent	$S \ldots P_s$	voltampere	VA	
power — reactive	$Q \ldots P_q$	var	var	
resistivity	ρ	ohm-meter	Ω•m	
conductivity	γ, σ	siemens per meter	S/m	
electric flux	ψ	coulomb	C	
electric flux density, displacement	D	coulomb per sq meter	C/m^2	
electric field strength	E	volt per meter	V/m	
permittivity	ϵ	farad per meter	F/m	
relative permittivity	ϵ_r, κ	(numeric)		
magnetic flux	ϕ	weber	Wb	V•s
magnetomotive force	$F \ldots$	ampere (amp turn)		
reluctance	$R \ldots$	ampere per weber	A/Wb	
		reciprocal henry	H^{-1}	
permeance	$P \ldots$	weber per ampere	Wb/A	
		henry	H	
magnetic flux density	B	tesla	T	Wb/m^2
magnetic field strength	H	ampere per meter	A/m	
permeability (absolute)	μ	henry per meter	H/m	
relative permeability	μ_r	(numeric)		

V, E comma indicates alternate symbols
. . . *U* dots indicate reserve symbol

APPENDIX C

INTERNATIONAL SYSTEM OF UNITS (SI)
CONVERSION FACTORS

Conversion TO Metric Measures

Symbol	Given	Multiply by	To Obtain	Symbol
LENGTH				
in	inches	25.4*	millimeters	mm
ft	feet	30.48*	centimeters	cm
yd	yards	0.9144*	meters	m
mi	miles (statute)	1.609	kilometers	km
nmi	miles (nautical)	1.852*	kilometers	km
	micron	1.0*	micrometers	µm
A	angstrom	0.1*	nanometers	nm
AREA				
cmil	circular mils	0.0005067	sq millimeters	mm^2
in^2	square inches	6.452	sq centimeters	cm^2
ft^2	square feet	0.09290	sq meters	m^2
yd^2	square yards	0.8361	sq meters	m^2
mi^2	sq miles (statute)	2.590	sq kilometers	km^2
	acres	0.4047	hectares(10^{4}m^2)	ha
VOLUME				
fl oz	fluid ounces(US)	29.57	cubic cm (millimeters)	cm^3 or ml
gal	gallons (US liq)	3.785	liters	l
gal	gallons (Canada)	4.546	liters	l
in^3	cubic inches	16.39	cu centimeters	cm^3
ft^3	cubic feet	0.02832	cubic meters	m^3
yd^3	cubic yards	0.7646	cubic meters	m^3
bbl	barrels (US petro)	0.1590	cubic meters	m^3
	acre feet	1233.5	cubic meters	m^3
SPEED				
ft/min	feet per minute	5.080*	millimeters per second	mm/s
mi/h	miles per hour	0.4470	meters per sec	m/s
km/h	kilometers per hr	0.2778	meters per sec	m/s
kn	knots	0.5144	meters per sec	m/s
MASS				
oz	ounces (avdp)	28.35	grams	g
lb	pounds (avdp)	0.4536	kilograms	kg
ton	short tons (2000 lbs)	0.9072	metric tons (1000 kg)	t
DENSITY				
lb/ft^3	pounds per cubic foot	16.02	kilograms per cubic meter	kg/m^3

APPENDIX C

Conversion TO Metric Measures

Symbol	Given	Multiply by	To Obtain	Symbol
FORCE				
oz_f	ounces-force	0.2780	newtons	N
lb_f	pounds-force	4.448	newtons	N
kg_f	kilograms-force	9.807	newtons	N
dyn	dynes	10^{-5}*	newtons	N
WORK, ENERGY — POWER				
$ft\text{-}lb_f$	foot opnds-force	1.356	joules	J
cal	calorie (thermochem)	4.184*	joules	J
Btu	British thermal units (Intl)	1055.	joules	J
hp	horsepower (elec)	746.*	watts	W
$ft\text{-}lb_f/s$	foot pounds-force per second	1.356	watts	W
Btu/h	British thermal units per hour (Intl)	0.2931	watts	W
PRESSURE				
lb_f/in^2	pounds-force/inch^2	6.895	kilopascals	kPa
lb_f/in^2	pounds-force/foot^2	47.88	pascals	Pa
kg_f/m^2	kilograms-force/meter^2	9.807	pascals	Pa
mb	millibars	100.0*	pascals	Pa
mmHg	millimetrs of Hg	133.3	pascals	Pa
inH_2O	inches of water (39°F)	0.2491	kilopascals	kPa
ftH_2O	feet of water	2.989	kilopascals	kPa
LIGHT				
fc	footcandles	10.76	lux	lx
fL	footlamberts	3.426	candelas per sq meter	cd/m^2

Symbol	To Obtain	Divide by	Given	Symbol

Conversion FROM Metric Measures

TEMPERATURE

Symbol	Given	Compute by	To Obtain	Symbol
°F	°Fahrenheit	$(°F-32)\frac{5}{9}$	°Celsius	°C
°C	°Celsius	$°C\frac{9}{5}+32$	°Fahrenheit	°F

* Indicates exact value   5 omit when rounding

APPENDIX C

OTHER QUANTITIES

Quantity	Qty. Symbol	SI Unit	Unit Symbol	Identical Unit
length	l	meter	m	
mass	m	kilogram	kg	
time	t	second	s	
frequency	f, υ	hertz	Hz	1/s
angular frequency	ω	radian per sec	rad/s	
area	$A \ldots S$	sq meter	m^2	
volume	V	cubic meter	m^3	
velocity	v	meter per second	m/s	
acceleration (linear)	a	meter per sec^2	m/s^2	
force	F	newton	N	
torque	$T \ldots M$	newton meter	N•m	
pressure	p	pascal	Pa	N/m^2
temperature (absolute)	$T \ldots O$	kelvin	K	
temperature (customary)	$t \ldots \theta$	degree Celsius	°C	
attenuation coefficient	α	neper per meter	Np/m	
phase coefficient	β	radian per meter	rad/m	
propagation coefficient ($\gamma = \alpha + j\beta$)	γ	reciprocal meter	m	
radiant intensity	I	watt per steradian	W/sr	
radiant flux	P, ϕ	watt	W	
irradiance	E	watt per sq meter	W/m^2	
luminous intensity	I	candela	cd	
luminous flux	ϕ	lumen	lm	
illuminance	E	lux	lx	lm/m^2

PHYSICAL CONSTANTS

electronic charge	e	1.602×10^{-19} C
speed of light in vacuum	c_0	2.9979×10^{8} m/s
permittivity of vacuum, elec const	ϵ_0	8.854×10^{-12} F/m
permeability of vacuum, mag const	μ_0	$4\pi \times 10^{-7}$ H/m
Planck constant	h	6.626×10^{-34} J•s
Boltzmann constant	k	1.38×10^{-23} J/K
Faraday constant	F	9.649×10^{4} C/mol
standard gravitational acceleration	g_n	9.807 m/s^2
normal atmospheric pressure	atm	101.3 kPa

FACTOR, UNIT PREFIX, SYMBOL

10^{12}	tera	T	10^{1}	deka	da	10^{-6}	micro	μ
10^{9}	giga	G				10^{-9}	nano	n
10^{6}	mega	M	10^{-1}	deci	d	10^{-12}	pico	p
10^{3}	kilo	k	10^{-2}	centi	c	10^{-15}	femto	f
10^{2}	hecto	h	10^{-3}	milli	m	10^{-18}	atto	a

Rechargeable Battery

AC Operation

Connect the charger to any standard electrical outlet and plug the jack into the Calculator. After the above connections have been made, the power switch may be turned "ON." (While connected to AC, the batteries are automatically charging whether the power switch is "ON" or "OFF.")

Battery Operation

Disconnect the charger cord and push the power switch, "ON," an interlock switch in the calculator socket will prevent battery operation if the jack remains connected. With normal use a full battery charge can be expected to supply about 2 to 3 hours of working time.

When the battery is low, figures on display will dim. Do not continue battery operation, this indicates the need for a battery charge. Use of the calculator can be continued during the charge cycle.

Battery Charging

Simply follow the same procedure as in AC operation. The calculator may be used during the charge period. However, doing so increases the time required to reach full charge. If a power cell has completely discharged, the calculator should not be operated on battery power until it has been recharged for at least 3 hours, unless otherwise instructed by a notice accompanying your machine. Batteries will reach full efficiency after 2 or 3 charge cycles.

Disposable Battery Model (D)

Your calculator uses a standard nine-volt battery type 006P available at most drug, department and camera stores. To operate, disconnect the adaptor cord and turn power switch "ON" (an interlocking switch in the AC socket will prevent battery use if the plug remains connected). When the battery weakens, display will dim.

Experience has proven that batteries packed with machines age considerably. To protect your calculator, we have omitted the battery from the package. Please ask your dealer for a fresh, new power cell. In the event your brand new machine does not function, please check the battery first.

Please note, machines with disposable batteries will not recharge. See battery replacement details above.

AC Adapter Operation

It is recommended that you unsnap and remove the battery from your machine before inserting the adapter jack.

Use proper Commodore/CBM adapter-recharger for AC operation and recharging.

Adapter 640 or 707 North America

Adapter 708 England

Adapter 709 West Germany

APPENDIX E

Low Power
If battery is low calculator will:
a. Display will appear erratic
b. Display will dim
c. Display will fail to accept numbers

If one or all of the above conditions occur, you may check for a low battery condition by entering a series of 8's. If 8's fail to appear, operations should not be continued on battery power. Unit may be operated on AC power. See battery charging explanation. If machine continues to be inoperative see guarantee section.

CAUTION
A strong static discharge will damage your machine.

Shipping Instructions:
A defective machine should be returned to the authorized service center nearest you.
See listing of service centers.

Temperature Range

Mode	Temperature °C	Temperature °F
Operating	0° to 50°	32° to 122°
Charging	10° to 40°	50° to 104°
Storage	—40° to 55°	—40° to 131°

APPENDIX F

Guarantee

Your new electronic calculator carries a parts and labor guarantee for one year from date of purchase.

We reserve the right to repair a damaged component, replace it entirely, or, if necessary, exchange your machine.

If you own a portable calculator which uses an AC adapter, the adapter must be returned with your machine when service is required.

In order to receive free service under this guarantee at a Commodore Service Center, you are required to pay all postage, shipping and insurance charges when returning your calculator to the Commodore Service Center and enclose a check or money order for $2.50 to cover handling charge, return postage and insurance.

This guarantee is valid only when a copy of your original sales slip or similar proof of purchase accompanies your defective machine.

This guarantee applies only to the original owner. It does not cover damage or malfunctions resulting from fire, accident, neglect, abuse or other causes beyond our control.

The guarantee does not cover the repair or replacement of plastic housings or transformers damaged by the use of improper voltage. Nor does it cover the replacement of expendable accessories and disposable batteries.

The guarantee will also be automatically voided if your machine is repaired or tampered with by any unauthorized person or agency.

In order to record your guarantee you must complete the registration card and mail it within ten days from date of purchase.

This guarantee supersedes, and is in lieu of, all other guarantees whether expressed, or implied.

Sales and Service Centers

Commodore Business Machines, Inc.
390 Reed Street,
Santa Clara, California 95050

Commodore Business Machines, (Canada) Ltd.
946 Warden Avenue
Scarborough, Ontario

CBM Business Machines Limited
Eaglescliffe Industrial Estate
Stockton on Tees
Cleveland County
TS16 OPN
England

Commodore Buromaschinen GmbH
6079 Sprendlingen
Robert-Bosch-Str. 12A
West Germany

Commodore Japan Ltd.
Taisei-Denshi Bldg.
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Asahi-Ku, Osaka 535

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39 Rue Victor Masse
75009 Paris, France

Commodore Switzerland S.A.
Bahnhofstrasse 74,
CH-5000 AARAU, Switzerland

200654-01 Printed in Japan

Guarantee Registration Card

Please complete this card and mail today to the office nearest you.

Your name ______________________

Company name ______________________

Address ______________________

City ________ State ________ Zip ________

Model Designation ______________________

Serial Number ______________________

Name of Retailer ______________________

Address ______________________

Date of Purchase ______________________