commodore

Multi-Function Preprogrammed Rechargeable Scientific Notation Calculator

SR 9190R

P[illegible] USE

[illegible] USAGE

OWNER'S MANUAL

301 557-01 Rev. A

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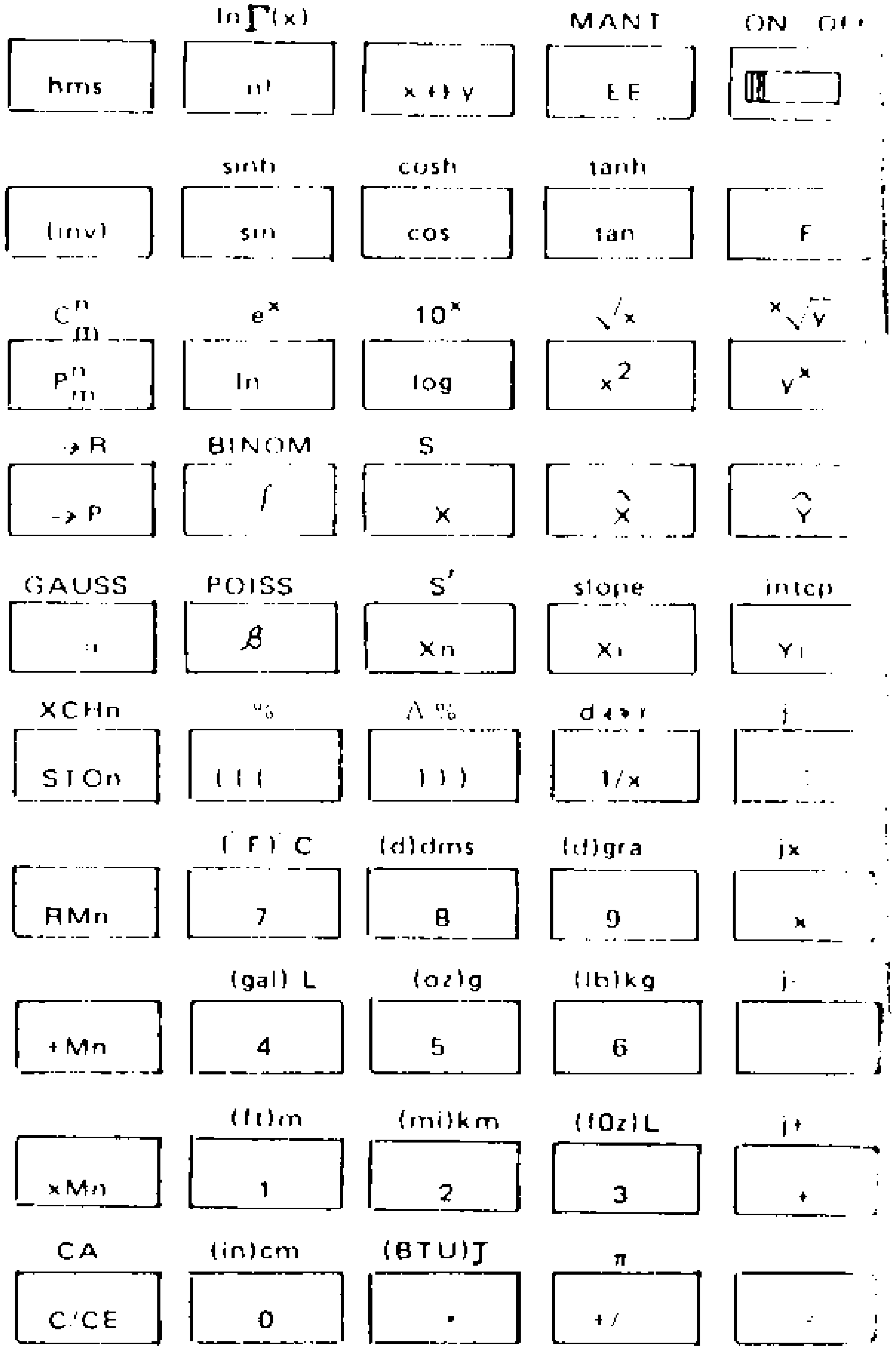


KEYBOARD LAYOUT

II. OPERATING INSTRUCTIONS – FUNDAMENTAL

1. Power On

To switch on the calculator, move the switch to the left. Zero in display indicates that power is on.

2. Display Format

At most, fourteen digits (including signs) can be displayed on your calculator.

Sample display:

-0. 1 2 3 4 5 6 7 8 9	9 0

sign of mantissa — mantissa — sign of exponent — exponent

The mantissa is a maximum of ten digits with or without a decimal point. The sign of the mantissa is positive if the mantissa field is blank and negative if the mantissa field contains a "–" sign.

The exponent is a maximum of two digits. The sign of the exponent is positive if the exponent field is blank and negative if the exponent field contains a "–" sign.

Your calculator has two display dot indicators, one (left end of display) to indicate the upper function key mode, and the other (right of the second exponenet digit) to signify radian mode."

Sample display:

2 •1 4 6 7 5 4 9 8 •

in radian mode

Error Display

If an improper operation is attempted, the word ERROR will appear on your display. To clear the ERROR display, press $\boxed{\text{C/CE}}$.

3. Numerical Entry

Enter in a positive number by pressing the digit keys in order, from left to right. When not entered, the decimal point is assumed to be to the right of the least significant digit, which is the last number entered.

To enter negative numbers, simply enter as a positive and then depress $\boxed{+/-}$.

To enter exponents, enter the mantissa (maximum 10 digits) and then depress $\boxed{\text{EE}}$ and enter in the exponent number (maximum 2 digits). To enter in a negative exponent, depress $\boxed{+/-}$ after entering in the exponent number. To modify the mantissa, when the calculator is in an exponent mode, depress $\boxed{\text{F}}$ MANT . This puts the calculator in mantissa mode. The exponent is cleared when the calculator is put in mantissa mode. Therefore, after modifying the mantissa, depress $\boxed{\text{EE}}$ and re-enter the exponent.

4. Upper Function Control Key and Inverse Keys $\boxed{\text{F}}$ $\boxed{\text{(inv)}}$

The $\boxed{\text{F}}$ key is depressed when an upper case function is required

The $\boxed{\text{(inv)}}$ key is reqiured for obtaining the following inverse functions: $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, and the inverses of the unit conversions.

To

To obtain the inverse function, say $\sin^{-1}$, simply enter the number followed by $\boxed{\text{(inv)}}$, $\boxed{\text{Sin}}$.

NOTE: *When requiring the upper case inverse functions (such as the Hyperbolic Functions), the order of entry of the* $\boxed{F}$ *and* $\boxed{(inv)}$ *keys is not important.*

If the $\boxed{F}$ *key is entered accidently, depress it once more to remove it from that mode.*

5. Clearing

a. To clear an erroneous entry while keeping prior numerical entries intact, depress $\boxed{\text{C/CE}}$ once.

EXAMPLE: 4 ÷ 2 $\boxed{\text{C/CE}}$ 4 $\boxed{=}$ 1

Pressing $\boxed{\text{C/CE}}$ once clears the display.

b. To clear a calculation and allow for the entering of another calculation, depress $\boxed{\text{C/CE}}$ twice successively.

c. To clear the memory registers, as well as the display, depress $\boxed{\text{F}}$ CA

d. To clear the calculation as well as the memory registers, switch off the power and switch it on again.

6. Simple Arithmetic

Four Functions $\boxed{+}$ $\boxed{-}$ $\boxed{\times}$ $\boxed{\div}$

To perform simple addition, subtraction, multiplication or division, simply enter as the problem appears: Example x + y + z

KEY ENTRY	DISPLAY	EXPLANATION
x	x	
$\boxed{+}$	x	for simple addition*
y	y	
$\boxed{+}$	y	
z	z	
$\boxed{=}$	x + y + z	

*For simple subtraction, miltuplication or division, simply press the required key (i.e., $\boxed{-}$, $\boxed{\times}$, or $\boxed{\div}$).

Remark: The $\boxed{=}$ key presents the final answer. There is no need to enter the $\boxed{=}$ key after the first operation since the result is displayed after the function key is depressed.

7. Chained Calculations

Chained calculations involving several operations such as the calculation of the sum of products or the product of sums can be carried out by using parantheses, refer to next page. Simple chaining can be carried out as follows:

Example: $\frac{X \times Y}{z} \div W$

KEY ENTRY	DISPLAY
x	x
$\boxed{\times}$	x
y	y

KEY ENTRY	DISPLAY
$\boxed{\div}$	X x y
z	z
$\boxed{\div}$	$\frac{X \times y}{z}$
W	W
$\boxed{=}$	$\frac{X \times y}{z} \div W$

Note: Chaining can be carried out with most functions although it is not available for certain advanced functions. See the table in the section on parentheses for the limitations on chained calculations.

8. Parentheses

Three levels of parentheses are provided on your calculator. Parentheses allow for straight-forward entry of more complex algebraic expressions such as sum of products.

EXAMPLE: Evaluate: $\frac{(5 \times 2) + (7 \times 3)}{(4 \times 8) + (9 \times 9)}$

KEY ENTRY	DISPLAY
$\boxed{(((}$	0
5	5
$\boxed{\times}$	5
2	2
$\boxed{)))}$	10
$\boxed{+}$	10

KEY ENTRY	DISPLAY
(((	10
7	7
×	7
3	3
)))	21
÷	31
(((	31
(((	31
4	4
×	4
8	8
)))	32
+	32
(((	32
9	9
×	9
9	9
)))	81
)))	113
=	274336283

Trigonometric, logarithmic and exponential functions may be used within parentheses.

EXAMPLE: Evaluate

$$\frac{e^{(\sin 50 + \cos 23)}}{2} \times \ln 8 \quad :$$

KEY ENTRY	DISPLAY
(((	0
50 sin	0.766044443
+	0.766044443
23 cos	.920504853
)))	1.686549297
F e^x	5.400811913
×	5.400811913
8 ln	2.079441542
÷	11.23067265
2	2
=	5.615336326

The contents of user memories may also be recalled within parentheses.

Parentheses and Chaining

The three levels of parentheses may not be used when certain advanced functions are being computed. Similarly it is not possible to perform chained calculators with some functions. The table below provides the list of functions in which parentheses or chaining may not be available to the user.

Function	Use of parentheses	Chained Calculation
Rectangular/ Polar Conversion	not allowed	not allowed
Natural log of gamma	allowed	not allowed
Permutations & Combinations	not allowed	allowed
Poisson density function	not allowed	allowed
Binomial density function	not allowed	allowed
Gaussian probability function	not allowed	allowed
Linear Regression	not allowed	not allowed
Mean & Standard Deviation	allowed	allowed
Numerical Integration	not allowed	not allowed
Complex Number Arithmetic	not allowed	not allowed

Also. Memory Registers 7,8 & 9 cannot be used when the user is using the three levels of parentheses. The calculator provides great flexibility in that if only one level of parentheses is needed then memories 1 - 8 are available, when two levels are required then memories 1 - 7 are available, and with all these levels of parentheses in use then memories 1 - 6 are available.

9. **Single Variable Functions**

Finding square of numbers $\boxed{x^2}$

To find the square of a number, enter the number, then depress $\boxed{x^2}$

Finding square root of numbers $\sqrt{x}$

To obtain the square root of a number, enter the number, then depress $\boxed{F}$ $\sqrt{x}$

Note: Valid for $X \geq 0$

Finding reciprocal of numbers $\boxed{1/X}$

The reciprocal of a number can be obtained by entering in the number and then depressing the key $\boxed{1/X}$.

Note: Not valid for $x = 0$

Finding natural logarithm of numbers $\boxed{\ln}$

To find the natural logarithm of a number, enter the number, then depress $\boxed{\ln}$.

Note: $x > o$.

Finding e to the power x $\boxed{F}$ e^x

To obtain e to the power x, enter the number x, then key in $\boxed{F}$ e^x .

Finding common logarithm of numbers log

The common logarithm of a number can be obtained by entering in the number and then depressing log .

Note: $x > 0$.

Finding common antilog of numbers 10^x

To calculate the common antilog of a number, enter the number, then key in $\boxed{F}$ 10^x .

Finding trigonometric functions [Sin], [Cos], [tan] [inv]

To find the sine of a number in degrees enter the number and then depress [Sin]. The cosine and tangent can be obtained similarly.
If you want to calculate the Sine of a number in radians, set the calculator in the radian mode by pressing [F] d↔r and then enter in the numbi followed by [Sin].
Cosine and tangent can be found similarly.

To find the inverse sin of a number, $\sin^{-1}$ enter the number then depress [inv] [sin]. The inverse of the cosine and tangent can be obtained similarly.

Note: (1) inverse sine and cosine → |x ≤ 1
(2) also tan 90° or tan π/2 is invalid

Finding factorials [n!]

To obtain the factorial of an integer on display, press [n!]

Note: n! is obtained if n < 69. For n > 69. use lnΓ(x) (refer to example).

10. Double functions

Finding y to the power x [y^x]

To raise a positive number to any power, enter as follows:

KEY ENTRY	DISPLAY
y	y
[y^x]	y
x	x
[=]	y^x

Note: x can be an integer or a decimal, negative or positive.

Finding y to the root x [F] $\sqrt[x]{y}$

To obtain the X root, of any positive number y, enter as follows:

KEY ENTRY	DISPLAY
y	y
[F] $\sqrt[x]{y}$	y
x	x
[=]	$\sqrt[x]{y}$

Note: x can be negative or positive, an integer or a decimal. However, y may only be positive.

Using the Exchange Register Key x↔y

The exchange key, x↔y reverses the order of the operands. For instance, x ÷ y will become y ÷ x. The exchange key can be used as follows:

KEY ENTRY	DISPLAY
[x]	x
[÷]	x
[y]	y
[x↔y]	x
[=]	y ÷ x

Note: (1) The exchange register key may be used for the following operations: division, subtraction, power and root.
(2) Note also that the excnange key is used for entering and obtaining calculations for the following functions:

a. [∫] Numerical integration
b. Complex arithmetic
c. [→P] Rectangular to polar conversion
d. →R Polar to rectangular conversion
e. Δ% Percent difference

11. **Degree/Radian Conversions & Modes**

For either a degree/radian conversion or a change of degree/radian mode, press:

$\boxed{F}$ d↔r

Pressing the above will both do the conversion and reset the mode. In other words, if the calculation is in degree mode and F d↔r is pressed, a degree to radian conversion is done and the calculator is put in radian mode. Likewise, if the calculator is in radian mode and F d↔r is pressed, a radian to degree conversion is done and the calculator is put in degree mode.

Rules for determining the calculator's mode are

1) When turned on, the calculator is initially in degree mode.
2) If there is a decimal point in the exponent field of the display, the calculator is in radian mode. If not, the calculator is in degree mode.

12. **Conversions**

(a) Rectangular/Polar Coordinates $\boxed{\to P}$ $\to R$

(b) Degree to Radian Conversion d↔r

(c) Unit Conversions

The unit conversions available on the calculator are as follows:

		Conversion Factor	
Length		**Unit 1 to Unit 2**	**Unit 2 to Unit 1**
(ft) m	feet to meters	0.3048	3.28839895

		Conversion factor	
Length		**Unit 1 to Unit 2**	**Unit 2 to Unit 1**
(mi) km	miles to kilometers	1.609344	0.621371192
(in)cm	inches to centimeters	2.54	0.393700787
MASS			
(lb)kg	pounds to kilograms	0.45359237	2.204622622
VOLUME			
(gal) L	gallons (IMP) to litres	4.546279553	0.219960076
(fl oz) L	Fluid ounces (US) to litres	0.0295735296	33.81402266
ENERGY			
(BTU) J	BTU to joules	1055.055853	$9.478171203 \times 10^{-4}$
TEMPERATURE			
(°F) °C	degrees fahrenheit to degrees centigrade	(°F-32) ÷ 1.8	$(°C \times \frac{5}{9}) + 32$

4. Miscellaneous Conversions

(d) gra — degree to grads

(d) dms — degree to degrees (hours)-minutes-seconds.

To convert the display in UNIT 1 to UNIT 2 enter F (1) 2.

To convert the display in UNIT 2 to UNIT 1 enter F INV (1) 2.

3. User Memories

There are a maximum of nine memories available to the user. The nine memories will be referred to as registers from 1 to 9. All 9 memories may not be available to the user when certain advanced functions are being evaluated. Many of the problems presented provide excellent use of the memory registers. Refer to section 13 f. for limitations in the use of the memories.

a. Storing the Display in User Memory STO_n

For storing a number on display in a memory, simply depress: STO_n followed by an arbitrary number from 1 to 9 (these are the 9 memory registers available to the user).
For example to store 234 into register 2, simply enter 234, then depress STO_n 2.

b. Recalling the Quantity Stored in User Memory RM_n

For recalling a value stored in a memory register, simply depress RM_n followed by the memory register (number 1 to 9) in which the value is stored.

For example To recall the value stored in register 2, simply depress RM_n 2; value obtained on the display is 234.

c. Exchange User Memory and Display XCH_n

A very important operation available in the calculator is the exchange memory key XCH_n. The effect of XCH_n is to combine the effects of storing a new value and recalling the value stored earlier in one single step. To show how the XCH_n key is used, an example is presented below:

KEY ENTRY	DISPLAY	EXPLANATION
5 STO_n 1	5	5 in register 1
150 ÷	150	
25	25	
+	6	
F XCH_n 1	5	6 in register (new number)
=	11	6 + 5
RM_n 1	6	

d. Four Function User Memories and Display +Mn n, XMn

Other important operations available in the calculator are simple arithmetic operations that can be carried out directly to the memory without the need to recall the value. This means that a new value a can be added, subtracted, multiplied or divided directly to a value present in any memory register. A new modified value will then occupy the memory register.

(1) To ADD a to the quantity present in memory register 1, enter a, press +Mn 1

(2) To SUBTRACT a from the quantity present in memory register 1, enter a, press +/− +Mn 1

(3) To MULTIPLY the quantity present in memory register 1 by the value a, enter a, press $\boxed{XMn}$ 1

(4) To DIVIDE the quantity present in memory register 1 by the value a, enter a, press $\boxed{1/x}$ $\boxed{XMn}$ 1

Note: The value a can be added/subtracted to/from a quantity present in any memory register. Similarly for multiplying/dividing the quantity present in any memory register by the value a.

To illustrate this, evaluate

$P_3^5 = 3!\ C_3^5$

KEY ENTRY	DISPLAY	EXPLANATION
5 $\boxed{\alpha}$	5	
3 β $\boxed{F}$ C_m^n	9.999999999	
$\boxed{STO_n}$ 1	9.999....	Store in memory register 1
3 $\boxed{F}$ C_m^n	9.999....	C_3^5
3 $\boxed{n!}$	6	
$\boxed{XMn}$ 1	6	
$\boxed{RM_n}$ 1	60	6 × 10

e. Clearing the User Memories CA

To clear all the user memory registers, depress $\boxed{F}$ CA

If you want to clear only the value in one register, depress: O $\boxed{STO_n}$ n (n referring to the memory register that is to be cleared.)

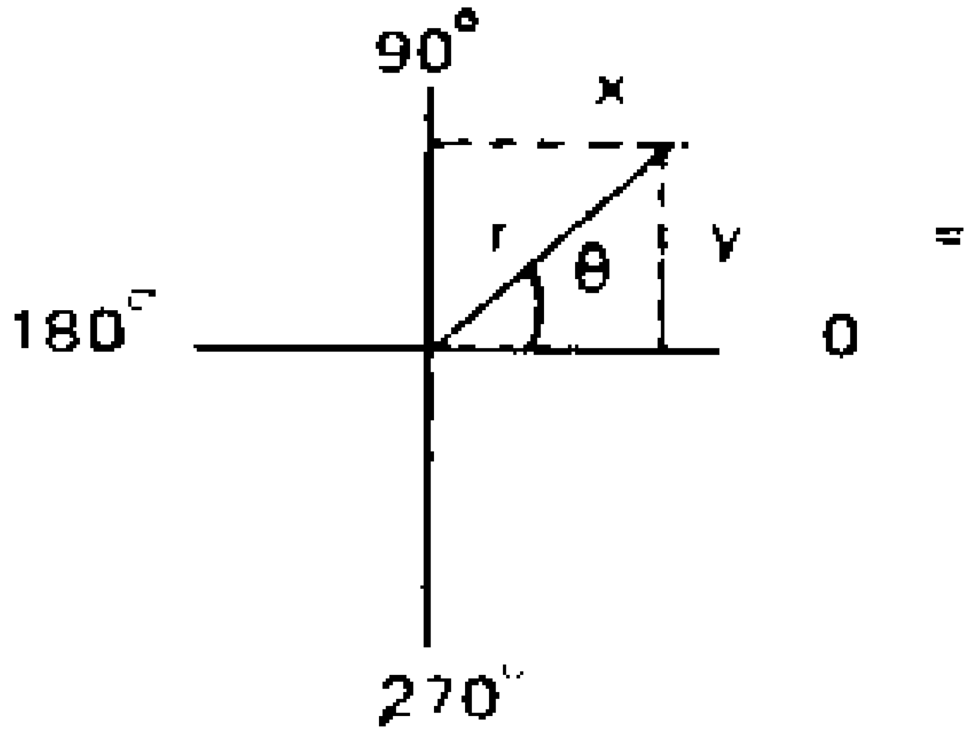
1. User Memory Register Limitations

All user memory registers are not available under certain conditions. The table below provides the list of the memories not available when using certain functions.

Function	Memory Registers Not available
Polar/ Rectangular Conversions	9
Natural log of gamma	9
Numerical Inegration	8, 9
Complex Number arithmetic	8,9
Permutations & Combinations	6,7,8,9
Poisson density function	8,9
Binomial density function	6,7,8,9
Gaussian probability function	8,9
Linear Regression	1-6,8,9
Mean & Standard deviation	4-6

III. OPERATING INSTRUCTIONS -- SPECIAL FUNCTIONS

1. Polar/Rectangular Conversions



The formulas for converting rectangular coordinates to polar coordinates are:

$$r = \sqrt{x^2 + y^2}$$

$$\theta = \tan^{-1} \frac{y}{x}$$

For converting polar to rectangular coordinates, the formulae are:

$$x = r \cos \theta \qquad y = r \sin \theta$$

a. Rectangular to Polar $\boxed{\to P}$

To convert (x,y,) to (r ,θ), the following key sequence is used:

KEY ENTRY	DISPLAY
x	x
$\boxed{x \leftrightarrow y}$	0
y	y
$\boxed{\to P}$	r
$\boxed{x \leftrightarrow y}$	θ

b. Polar to Rectangular →R

To convert (r ,θ) to (x,y) the following key sequence can be used:

KEY ENTRY	DISPLAY
r	r
$\boxed{x \leftrightarrow y}$	0
θ	θ
→R	x
$\boxed{x \leftrightarrow y}$	y

Note: (1) User memory register 9 is not available during rectangular/polar conversion.

(2) Chaining and Parenthesis are not available when using these conversions

2. Hour-Minutes-Second Function (Or Degrees-Minute-Second Function)

a. Hour-Minute-Second Entry.

To enter numbers in the hour-minute-second (or degree-minute-second) format, enter the hours or degrees (integer up to 9999) and then depress $\boxed{HMS}$. Minutes can be entered next followed by depressing $\boxed{HMS}$, then enter the seconds (Both the minutes and the seconds can be entered up to 99, in integer form)

Supposing we want to enter 30 degrees, 45 minutes and 10 seconds) enter as follows:

HMS	30·	
45	30·45	
HMS	30·45·	
10	30·45·10	30 degrees-45 minutes - 10 seconds

If the minutes or seconds entered are greater than 60, depressing an arithmetic operator or the equals key will normalize the answer.

b. Hour-Minute-Second Arithmetic

Arithmetic operations such as addition subtraction, multiplication or division can be carried out in the H-M-S format. Arithmetic operations where the first factor is expressed in the HMS mode and the second in decimal, will give results in the HMS mode. Addition or subtraction with both factors in the HMS mode will not change the mode.

However, if multiplication or division is carried out the result will appear in decimal form.

c. HMS/Decimal Conversion

To convert the decimal form into the HMS format (i.e. hours/degrees-minutes-seconds). depress F (d)dms.

To obtain the decimal form when the display is in the HMS mode, depress (inv) F (d)dms.

3. Natural Logarithm of Gamma, Function

The Gamma Function is given by the formula:

$$\Gamma(x) = \int_0^\infty e^{-t}\, t^{x-1}\, dt$$

The natural log of gamma as opposed to gamma is given in order to extend the range of x values for which gamma can be evaluated. To obtain the ln Γ(x), enter the following:

KEY ENTRY	DISPLAY
x	x
F lnΓ(x)	"lnΓ(x)"

Note: 1. Memory register 9 is not available and the use of parentheses are not allowed when using this function.

2. Applications of the gamma function are found in mathmatical physics and engineering.

3. The natural logarithm of gamma allows you to calculate factorials >69.

4. The Hyperbolic Functions

The hyperbolic functions are defined as follows:

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

$$\cosh x = \frac{e^x + e^{-x}}{2}$$

$$\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

To obtain the hyperbolic sine of x, enter x and then depress F sinh . The hyperbolic cosine and hyperbolic tangent can be obtained similarly.

To calculate the inverse of the hyperbolic functions, enter the number followed by F (inv) sinh. The inverse of tanh and cosh can be obained similarly.

Note: The inverse hyperbolic functions are defined as follows:

$$\sinh^{-1} x = \ln(x + \sqrt{x^2 + 1})$$

$$\cosh^{-1} x = \ln(x + \sqrt{x^2 - 1})$$

$$\tanh^{-1} x = \tfrac{1}{2} \ln\left(\frac{1 + x}{1 - x}\right)$$

5. Numerical Integration

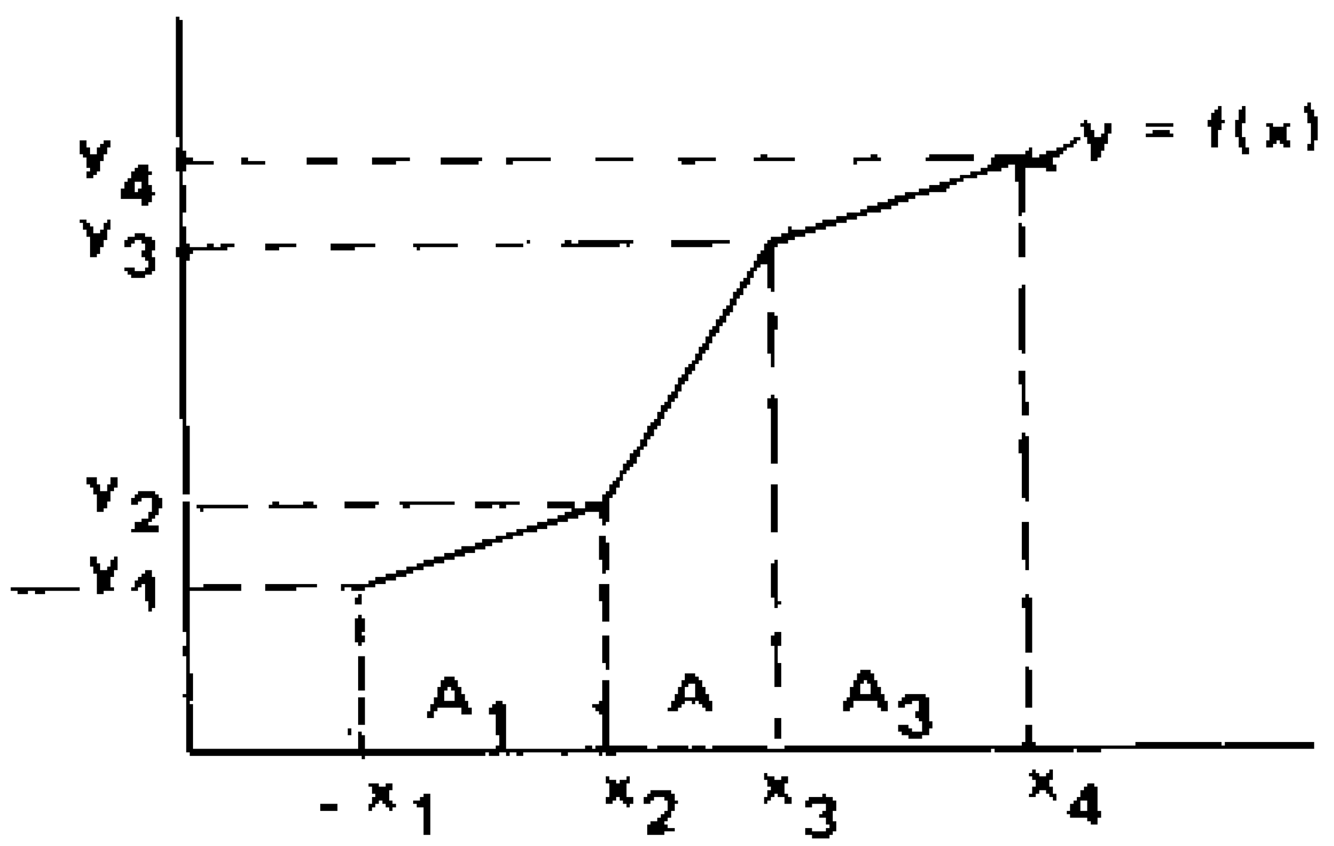
The numerical integration in this calculator uses the trapezoidal rule, which is given by:

$$\int_{x_o}^{x_n} F(x)dx \simeq \tfrac{1}{2}h\left[y_o + 2y \quad + \ldots + 2y_{n-1} + y_n\right]$$

Its trunction error is approximately ·

$$\frac{(x_n - x_o)\, h^2\, y^2(\xi)}{12}$$

To numerically integrate between two end points, $(x_1 y_1)$ and $(x_4\ y_4)$ having points (x_2, y_2) (x_3, y_3) in between, enter as follows:



$$\int_{x_1}^{x_4} f(x)dx = A_1 + A_2 + A_3$$

KEY ENTRY	DISPLAY	EXPLANATION
[F] CA	0	Clear calculator and memories
x_1	x_1	
[x↔y]	0	
y_1	y_1	Simple arithmetic may be used to evaluate y = f (x)
[∫]	0	
x_2	x_2	
[x↔y]		
y_2	y_2	
[∫]	$\int_{x1}^{x2}$	A_1
x_3	x_3	
[x↔y]		
y_3	y_3	
[∫]	$\int_{x1}^{x3}$	$A_1 + A_2$
x_4	x_4	
[x↔y]		
y_4	y_4	
[∫]	$\int_{x1}^{x4}$	$A_1 + A_2 + A_3$

Note: 1. Memory registers 8 & 9 are not available to the user.

2. Chaining and parentheses are not available.

3. Function x is defined by the order in which coordinates are entered.

4. Both the calculator and memory registers must be cleared prior to initial data entries.

6. Complex Arithmetic

Suppose $(x_1 + y_1 i)$ and $(x_2 + y_2 i)$ are complex numbers. To perform complex arithmetic, enter the following key sequence.

KEY ENTRY	DISPLAY	EXPLANATION
x_1	x_1	
x↔y	0	
y_1	y_1	
F j+	y_1	or any complex operation (F j·, F jx, F j-)
x_2	x_2	
x↔y	0	
y_2	y_2	

For the results, enter the following:

=	x_a	real part of result A
x↔y	y_a	imaginary part of result A

Results may be converted to polar coordinate form, using the →P →R conversion keys.

Note: (1) Parentheses are not available when performing complex arithmetic.

(2) Chained calculations may not be performed.

(3) Memories 8 and 9 are not available when performing complex arithmetic.

Percent Key %

The percent key displays a number entered as a percentage in decimal form. The percent key can be used with any of the four function keys (+,-,÷,X) to solve problems of mark up/mark down, tax add-on and chain discounts. Refer to the examples in the appendix

The following example shows how the % key may be used.

Find 8% of 210.

KEY ENTRY	DISPLAY
8	8
F %	8-02
×	8-02
210	210
=	16.8

Percent Difference. $\Delta\%$

The formula used for evaluating the percent difference is:

$$A \, \Delta\% \, B = \frac{B-A}{A} \times 100\%$$

The percent difference key calculates the percent difference between a base A and any number B. The result is given in (%) of the base.

To find the percent difference of A by a number B, enter as follows:

KEY ENTRY	DISPLAY
A	A
$\boxed{x \leftrightarrow y}$	0
B	B
$\boxed{F}$ $\Delta\%$	$\frac{B-A}{A}$ %

Refer to the appendix for examples of Δ % calculations.

IV. OPERATING INSTRUCTIONS— STATISTICAL FUNCTIONS

1. Permutation and Combination

C^n_m $\boxed{P^n_m}$

These are evaluated using:

$$P^n_m = \frac{n!}{(n-m)!}$$

$$C^n = \frac{n!}{m!(n-m)!}$$

Where n, m are integers and $0 < m < n$.

To find P^n_m, enter n and m as follows:

KEY ENTRY	DISPLAY
n	n
$\boxed{\alpha}$	n
m	m
$\boxed{\beta}$	m
$\boxed{P^n_m}$	P^n_m

To find C^n_m, enter n and m as follows:

KEY ENTRY	DISPLAY
n	n
$\boxed{\alpha}$	n
m	m
$\boxed{\beta}$	m
$\boxed{F}$ C^n_m	C^n_m

NOTE 1 Chaining and parentheses are not available for either P^n_m or C^n_m.

2. Poisson Density Function POISS

The Poisson Probability Mass Function is evaluated using:

$$\text{POISS}(k) = \frac{\lambda^k e^{-\lambda}}{n} \quad \text{Where } \lambda > 0 \text{ and } k = 0,1,2,\ldots\ldots$$

To obtain the Poisson Probability Mass Function, enter as follows:

KEY ENTRY	DISPLAY
k	k
[α]	k
λ	λ
[F] POISS	POISS (K)

Note: 1. Memory registers 8 & 9 are not available when evaluating the Poisson Density function.

2. Parentheses are not available when using this function but chaining is allowed.

3. Binomial Density Function BINOM

The Binomial Density Function is evaluated using:

$$BIN(K) = C^n_K \cdot P^K \cdot Q^{n-K}$$

Where n is a positive integer and $0 < P < 1$ and $K = 0, 1, 2, \ldots, n$ $Q = 1 - P$

To evaluate the Binomial Density Function enter as follows:

KEY ENTRY	DISPLAY
n	n
[α]	n
k	k
[β]	k
P	P
[F] BINOM	BIN (K)

Note: 1. Memory registers 6,7,8,9 are not available when evaluating the Binomial Density function.

2. Parentheses are not available when using this function but chaining is allowed.

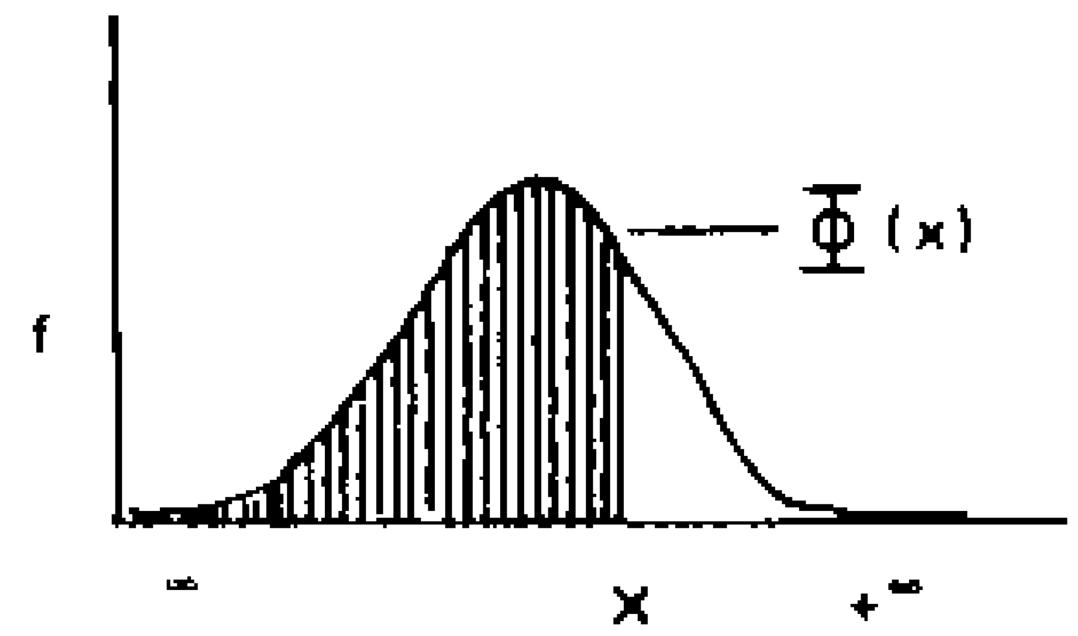
4. Guassian Probability Distributiun GAUSS

The Gaussian Probability Distribution function (Φ) is evaluated using:

$$\Phi(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} e^{-Y^2/2} \, dY$$

where $-\infty < x < \infty$

To evaluate $\Phi(x)$, enter x then depress [F] GAUSS



Gaussian Distribution curve

Note: 1) Memory registers 8 and 9 are not available when evaluating this function
2) Parentheses are not allowed but chainging can be used.

5. Linear Regression

Before entering data for this function clear all data registers by pressing [F] CA

A series of points on a graph may be approximated to the straight line $y = mx + c$ where m is the slope and c the intercept. By entering data points x_i, y_i, the calculator will compute m and c automatically using the following equations.

$$m = \frac{n \sum_{i=1}^{n} x_i \Sigma y_i - \sum_{i=1}^{n} x_i \Sigma y_i}{n \sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)2}$$

and

$$c = \frac{\sum_{i=1}^{n} y_i \sum_{i=1}^{n} x_i^2 - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} x_i y_i}{n \sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2}$$

where n is the number of data points entered.

This calculator has the ability to preserve the data base during the calculation of m and c allowing the user to add or delete data points at will and recompute the parameters of the best fit straight line.

To enter data

KEY ENTRY	DISPLAY	
[F] CA	0	
X_1	X_1	1st x
[X_i]	X_1	
Y_1	Y_1	1st y
[Y_i]	1	One data point entered
x_2	x_2	2nd x
[x_i]	x_2	
y_2	y_2	2nd y

KEY ENTRY	DISPLAY	
[Y_i]	2	Two data points entered
⋮		
x_n	x_n	n th y
[x_i]	x_n	
y_n	y_n	n th y
[Y_i]	n	

To find the value $\hat{y}$ corresponding to a value x enter x and press [$\hat{y}$] and similarly to obtain x corresponding to a value y enter y and press [$\hat{x}$]

The data base is preserved in memory registers 1 through 6 as follows.

MEMORY	1	2	3	4	5	6
QUANTITY	Σxy	Σy^2	Σy	Σx^2	Σx	n

DELETION OF POINTS

To delete a point x,y from the data base:

KEY	DISPLAY	
x	x	
[(inv] [xi]	x	
y	y	
[(inv)] [yi]	n –	number of points left.

New points may be added as before.

Note: 1) The number of points entered is unrestricted.

2) The data must be entered in pairs, x value entered first.

3) Only memory register 7 is available for independent use.

4) Neither parentheses nor chaining are available when using the linear regression function

5) The values of the data base stored in memories 1 through 6 are available by pressing [RM$_n$] followed by the required memory register address.

EXAMPLE

Suppose we have a set of points (x_i, y_i) with which we want to fit a straight line:

$y = \alpha + \beta x$ the data is given below

x	3	4	6	8
y	5	7	9	13

(a) the slope b (the best estimate of β).

(b) the intercept, a (the best estimate of α).

(c) fitted value of y for a corresponding x, where $\hat{y} = \alpha + \beta x$ let x = 9

(d) fitted value of x for a corresponding y, where $\hat{x} = \dfrac{y - \alpha}{\beta}$ let y = 15

Then the data may be entered as follows.

KEY ENTRY	DISPLAY
[F] CA	0
3	3
[x_i]	3
5	5
[y_i]	1
4	4
[x_i]	4
7	7

KEY ENTRY	DISPLAY
[y_i]	2
6	6
[x_i]	6
9	9
[y_i]	3
8	8
[x_i]	8
13	13
[y_i]	4
[F] Slope	1.525423729
[F] intcp	0.491525423
9 [$\hat{y}$]	14.22033898
15 [$\hat{x}$]	9.511111111

How to obtain the coefficient of correlation (γ)

The coefficient of correlation is given by:

$$\gamma = \frac{\Sigma x_i y_i - \dfrac{(\Sigma x_i)(\Sigma y_i)}{n}}{\left(\Sigma x_i^2 - \dfrac{(\Sigma x_i)^2}{n}\right)\left(\Sigma y_i^2 - \dfrac{(\Sigma y_i)^2}{n}\right)}$$

The formula used for evaluating the coefficient of correlation is given by:

$$r = \frac{\text{slope} \times \text{standard deviation of } x.}{\text{standard deviation of } y.}$$

Using the example given in linear regression, the following key sequence may be used:

KEY ENTRY	DISPLAY	EXPLANATION
[C/CE]	0	
[RM$_n$] 3	34	Σy_i
[x^2]	1156	$(\Sigma y_i)^2$
[÷]	1156	
4	4	
[=] [+/-]	-289	
[+]	-289	
[RM$_n$] 2	324	
[÷]	35	
3	3	
[=]	11.66666667	
[F] $\sqrt{x}$	3.415650255	Sy
[1/x]	0.292770021	
[×]	0.292770021	
[F] S	2.217355783	
[×]	0.649175301	
[F] Slope	1.525423729	
[=]	0.990267408	

How to obtain the Residual Sum of Squares (RSS)

The Residual Sum of Squares is evaluated using the following formula:

$$RSS = \Sigma y_i^2 - \text{intcpt} \times \Sigma y_i - \text{slope} \times \Sigma x_i y_i$$

To obtain the Residual Sum of Squares of the example enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
[F] slope [×]	1.525423729	$\Sigma x_i y_i$
[RM$_n$] 1	201	$\Sigma x_i y_i$
[ ] [+/-]	-306.6101695	
[+]	306.6101695	
[RM$_n$] 2	324	Σy_i^2
[ ]	17.38983051	
[STO$_n$] 7	17.38983051	
[F] intcp	0.491525423	
[×]	0.491525423	
[RM$_n$] 3	34	Σy_i
[=] [+/-]	-16.71186441	
[+] [RM$_n$] 7	17.38983051	
[=]	0.677966102	RSS

The standard error of estimate of y on x can be obtained by using the formula:

$$Sy.x = \sqrt{\frac{RSS}{n-2}}$$

6. Mean and Standard Deviation

Before entering data for mean and standard deviation, memory registers 4,5 and 6 have to be cleared by storing zero in each of the registers 4,5 and 6. Just in linear regression, your data base is preserved, and therefore depressing [$\bar{X}$] or [F] S or [F] S' does not destroy the data base. The data base is preserved as follows:

MEMORY REGISTER	QUANTITY
6	n
5	$\sum_{i=1}^{n} x_i$
4	$\sum_{i=1}^{n} x_i^2$

To retrieve a quantity, press [RM_n] followed by the required memory register.

Values can be deleted as in linear regression. To delete a value, enter [(inv)] number [X_n]

Supposing we are given a set of numbers 5.1, 5.8, 4.5, 5.5 and we want to evaluate

a. the Mean $\bar{X}$

$$\text{Where } \bar{X} = \frac{\sum_{i=1}^{n} x_i}{N}$$

b. standard deviation of the sample (unbiased),

$$\text{Where } S = \sqrt{\frac{\sum x_i^2 - N\bar{X}^2}{N-1}}$$

c. standard deviation of the population (biased),

$$\text{Where } S' = \sqrt{\frac{\sum x_i^2 - N\bar{X}^2}{N}}$$

d. standard error of sample,

$$\text{Where } S_x = \frac{S}{\sqrt{N}}$$

Then we can enter as follows

KEY ENTRY	DISPLAY	EXPLANATION
5.1	5.1	
[X_n]	5.1	
5.8	5.8	
[X_n]	5.8	
4.5	4.5	
[X_n]	4.5	
5.5	5.5	
[X_n]	5.5	
[$\bar{X}$]	5.225	
[F] [S]	0.56199051	standard deviation of sample
[F] [S']	0.486698058	standard deviation of population

and for the standard error of sample,

KEY ENTRY	DISPLAY	EXPLANATION
[RM_n] 6	4	N
[F] [$\sqrt{x}$]	2	$\sqrt{N}$
[1/x]	0.5	
[×]	0.5	
[F] [S]	0.56199051	$\frac{S}{\sqrt{N}}$
[ ]	0.28095255	Sx (standard error)

Remarks: (1) Clear memory registers 4,5 and 6 prior to entering data.

(2) Memory registers 4,5 and 6 are not available for user.

(3) The number of sample values is unrestricted.

(4) N is a positive integer, >1

(5) Both chaining and parentheses are allowed.

7. General Curve Fitting

Use transformation for dependent variable y given by $W_{(k)} = \frac{y^k - 1}{k}$

where $0 \leq k \leq 1$

Since $\lim_{k \to 0} W_{(k)} = \ln y$

k = 1 gives a linear fit and k $\to 0$ gives an exponential curve fit, K = 0.5 gives a quadratic curve fit and so on. Thus the above transformation gives a wide range of general curve fittings ranging from the linear to the exponential case.

Suggested procedure to be followed for practical examples:

Do a linear regression without using a transformation, Find the Residual Sum of Squares (RSS). Pick a value of k between 0 and 1 and use the above transformation for the y values. Find the RSS. Choose the k which gives the smallest RSS. Usually it is sufficient to enter the data only three to four times to get a good value of k.

V. APPLICATIONS – EXAMPLES

Rectangular to Spherical Conversion

Convert (2,5,8) given in rectangular coordinates to spherical coordinates (r, θ ϕ).

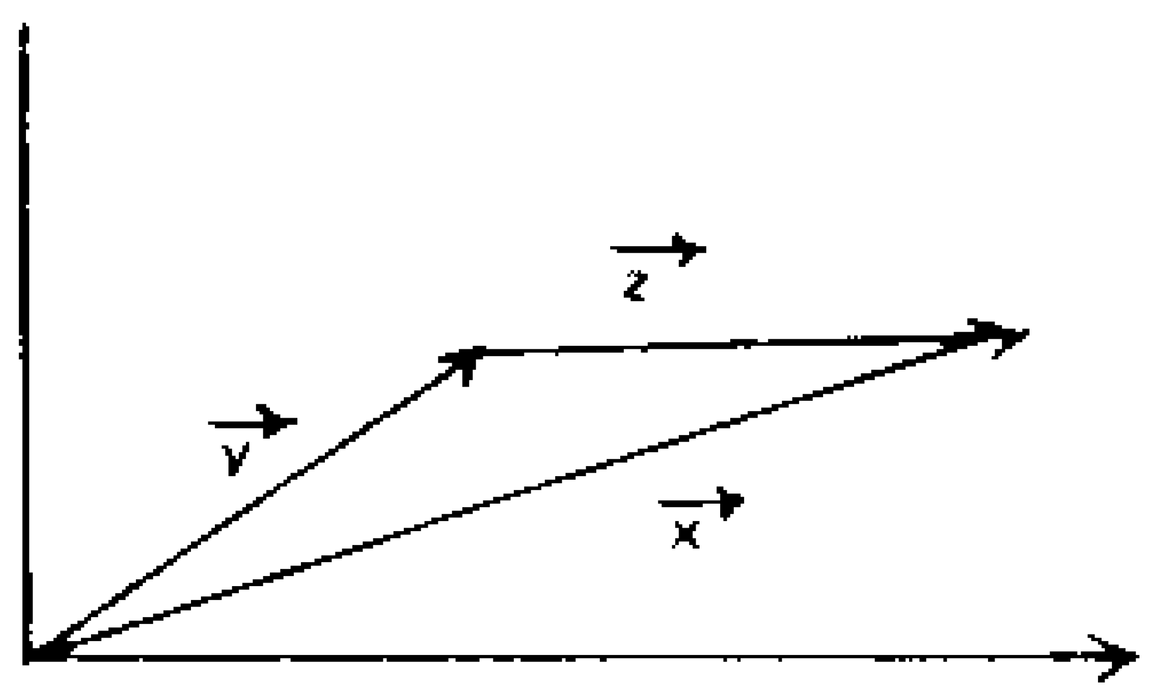
Solution:

Enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
2	2	enter x
[x<–>y]	0	
5	5	enter y
[→P]	5.385164807	r sin ϕ
[x<–>y]	68.19859051	get θ
8	8	enter z
[x<–>y]	5.385164807	r sin ϕ
[→P]	9.643650761	get r
[x↔y]	33.94629503	get ϕ

the coordinates are (9.6 4, 68.20, 33.9).

2. Vector Addition



Add the two vectors $\vec{X}$ = (7,27' 35' 22'') and (3,42 37' 30'')

Solution

The vectors in rectangular coordinates are given by

X_z (Xx+Xy)

Y_z · (Yx+Yy)

and in polar coordinates by

$\vec{X}$ = (Rx,Θx)

$\vec{Y}$ = (Ry,Θy)

$\vec{Z}$ = (Rz,Θz)

We have to find the resultant vector, $\vec{Z}$.

Enter as follows

KEY ENTRY	DISPLAY	EXPLANATION
7	7	enter Rx
[x<->y]	0	
27 [hms] 35 [hms] 22	27-35 22	enter Θx
[F] →R	6.204022418	get X_x
[STO$_n$] 1	6.204022418	Store Xx in memory register
[x<->y]	3.241929339	get Yx
[STO$_n$] 2	3.241929339	Store Yx in register 2
3	3	enter Ry

KEY ENTRY	DISPLAY	EXPLANATION
[x↔y]	6.204022418	
42 [hms] 37 [hms] 30	42-37-30	enter Θy
[F] →R	2.207405023	get Xy
[+M$_n$] 1	2.207405023	add Xy + Xx = Xz in register
[x↔y]	2.031591265	get Yy
[+M$_n$] 2	2.031591265	
	8.411427441	recall Xz
[RM$_n$] 1		
[X↔Y]	2.207405023	
[RM$_n$] 2	5.273520603	
[→P]	9.927846249	get Rz
[X↔Y]	32.08553912	get Θz in decimal degrees
[F] (d) dms	32-05-08	get Θz in degrees-minutes-seconds

3. Hour-Minute-Second Arithmetic

Example:

A milkman from a dairy normally takes 2 hours and 35 minutes to go to Daly City and it takes 45 minutes and 50 seconds from there to Palo Alto. How long does it take the milkman to reach Palo Alto?

Solution:

Enter as follows:

KEY ENTRY	DISPLAY
2 [HMS]	2
35 [HMS]	2-25-
0	2 35 0
[+]	2-35-00
0 [HMS]	0-
45 [HMS]	0-45-
50	0-45-50
[=]	3-20-50

The trip took 3 hours and 20 minutes and 50 seconds to Palo Alto.

b. Because of an accident on the highway, it took the milkman 4 hours, 10 minutes and 44 seconds. How late was the delivery?

Solution:

Enter as follows:

KEY ENTRY	DISPLAY
[+/-]	-3-20-50
[+]	-3-20-50
4 [HMS]	4-
10 [HMS]	4,10-
44	4-10-44
=	0-49-540

Therefore, the milkman was late by 49 minutes and 54 seconds.

4. Example: Hyperbolic Functions on Resonant Circuits

a Find the amplitude at resonance of a magnetic field if the terminations are dissipative. The attenuation factors are given by

$A_o = 0 \quad A_s = 1.77$

Also α gSp = 1.17. Let K = 2.4

b) Find the efficiency of the transmission, i.e. P_s/P_O.

c) Find the decibel loss

Solution:

the amplitude is given by,

$$K_p = \frac{K}{\sinh(\alpha\, gSp + A_s + A_o)}.$$

Enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
1.77	1.77	A_s
[+]	1.77	
1.17	1.17	gSp
[=]	2.94	
[F] sinh	9.431490292	
[1/X]	0.106027782	
[X]	0.106027782	
2.4	2.4	
[÷]	0.254466677	

Therefore, the amplitude is 0.25 to 2 decimal places.

b) to find the efficiency of the transmission, i.e. $\frac{P_s}{P_o}$, we use the relationship

$$\frac{P_s}{P_o} = \frac{\sinh\ 2\ A_s}{\sinh\ 2(agSp + A_s)}$$

Enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
1.77	1.77	
$\boxed{+}$	1.77	
1.17	1.17	
$\boxed{\times}$	2.94	
2	2	
$\boxed{=}$	5.88	
$\boxed{F}$ sinh	178.9032235	
$\boxed{1/X}$	5.58961421 -03	
$\boxed{STO_n}$ 1	5.58961421 -03	
1.77	1.77	
$\boxed{\times}$	1.77	
2	2	
$\boxed{=}$	3.54	
$\boxed{F}$ sinh	17.21895293	
$\boxed{XMn}$ 1	17.21895293	
$\boxed{RM_n}$ 1	9.624730398 -02	

The efficiency is 0.096;

c) We find the decibel loss by

$$\text{Loss (db)} = 10 \log_{10} \frac{P_o}{P_s}$$

Enter as follows:

KEY ENTRY	DISPLAY
$\boxed{RM_n}$ 1	9.624730398 -02
$\boxed{1}$	
$\boxed{x}$	10.38990142
$\boxed{\log}$	1.016611427
$\boxed{\times}$	1.016611427
10	10
$\boxed{=}$	10.16611427

Decibels loss = 10.17 to 2 decimal places.

5. Numerical Integration

Solve $\int_1^3 \frac{1}{x}\,dx$ = Using the trapezoidal rule.

x	1	1.5	2	2.5	3
y	y_1	y_2	y_3	y_4	y_5

Solution:

Enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
1	1	x_1

KEY ENTRY	DISPLAY	EXPLANATION
[x<->y]	0	
1	1	y_1
[1/x]	1	
[∫]	0	
1.5	1.5	x_2
[x<->y]	0	
1.5	1.5	
[1/x]	0.666666666	y_2
[∫]	0.416666666	
2	2	x_3
[x<->y]	0	
2	2	
[1/x]	0.5	y_3
[∫]	0.708333333	
2.5	2.5	x_4
[x<->y]	0	
2.5	2.5	y_4
[1/X]	0.4	
[∫]	0.933333333	
3	3	x_5
[x<->y]	0	
3	3	
[1/x]	0.333333333	y_5
[∫]	1.116666667	$\int_{x_1}^{x_5} 1/x\,dx$

Therefore $\int_1^3 1/x\,dx = 1.12$ using the trapezoidal rule.

Note: (1) The correct answer is $\left[\ln x\right]_1^3 =$ $\ln 3 - 0 = 1.0986$

(2) Clear memory registers by depressing [F] CA before starting a numerical integration.

6. Complex Arithmetic

The current in a circuit is given by (5.2 + j13) A when applied voltage is (100 + j150) volts. Determine the impedance stating whether it is inductive or capacitive.

Solution:

impedance = v/amperes

KEY ENTRY	DISPLAY	EXPLANATION
100	100	
[x<->y]	0	
150	150	
[F] j÷	150	
5.2	5.2	
[x<->y]	0	
13	13	
[=]	12.5994695	real part of ≙ impedance
[x<->y]	-2.652519894	imaginary part of ≙ impedance

The impedance is (12.60 - 2.65j) ohms.

Since the imaginary part is negative, the impedance is capacitive.

7. **Percentage (%) example on Tax Add-on**

An automobile retails for $5,200. If the sales tax is 6%, what is the dollar amount of the tax? What is the total cost of the car?

Solution:

Enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
5200	5200	
[+]	5200	
6	6	
[F] %̲	312	$ amount of tax
[=]	5512	total cost of the car

The amount of sales tax is $312.
The total cost of the car is $5,512.

8. **Percent Difference**

A man invests $4,500 in the stock market. Six months later he sells his stock for $6,200. What is the return on his investment.

Solution:

Enter as follows:

KEY ENTRY	DISPLAY
4500	4500
[x↔y]	0
6200	6200
[F] Δ%	37.77777778

The investor has realized a 37.8% return on his money.

9. **Permutation**

Given 15 students in a class and 6 desks in the front row, how many arrangements of students in all front row seats are possible?

Solution:

P_m^n where n = 15 and m = 6

Enter as follows:

KEY ENTRY	DISPLAY
15	15
[α]	15
6	6
[β]	6
[P_m^n]	3603600

Therefore, 3,603,600 arrangements are possible.

10. **Combination**

How many different bridge hands are there? Bridge is played with a 13 card hand dealt from 52 cards.

Solution:

hands = C_m^n where n = 52, m = 13

Enter as follows:

KEY ENTRY	DISPLAY
52	52
[α]	52
13	13
[β]	13

KEY ENTRY	DISPLAY
$\boxed{F}$ C^n_m	6.350135594 11

Therefore, there are $6.350135594 \times 10^{11}$ hands in bridge.

11. Poisson Density Function

A switchboard operator receives 48 calls during 8 hours. What is the probability of getting 2 calls during 10 minutes?

Solution:

We have $\lambda = \dfrac{48}{8 \times 60} = 0.1$ call/minute

Or $\lambda = 1$ call/10 minutes

The probability is POISS (k)

$$= \frac{e^{-\lambda} \lambda^k}{k!}$$

where $k = 2$ and $\lambda = 1$

Enter as follows:

KEY ENTRY	DISPLAY
2	2
$\boxed{\alpha}$	2
1	1
$\boxed{F}$ POISS	0.18393972

The probability of getting 2 calls/10 minutes is 0.184.

12. Binomial Distribution

Find the probability of getting exactly 2 heads in 6 tosses of a fair coin.

Solution:

$P(k) = C^n_k \, p^k \, q^{n-k}$ where $n = 6$, $k = 2$ and

$p = q = 0.5$

KEY ENTRY	DISPLAY
6	6
$\boxed{\alpha}$	6
2	2
$\boxed{\beta}$	2
.5	0.5
$\boxed{F}$ BINOM	0.234375

Probability of obtaining 2 heads = 0.234

13. Exponential Distribution

The probability of failure of an electronic device P = 3% per 6 weeks, operating hours. What is the probability for one device not to fail before 3 years?

Solution:

The probability is given by e^{-np} with n expressed in weeks. The key sequence is:

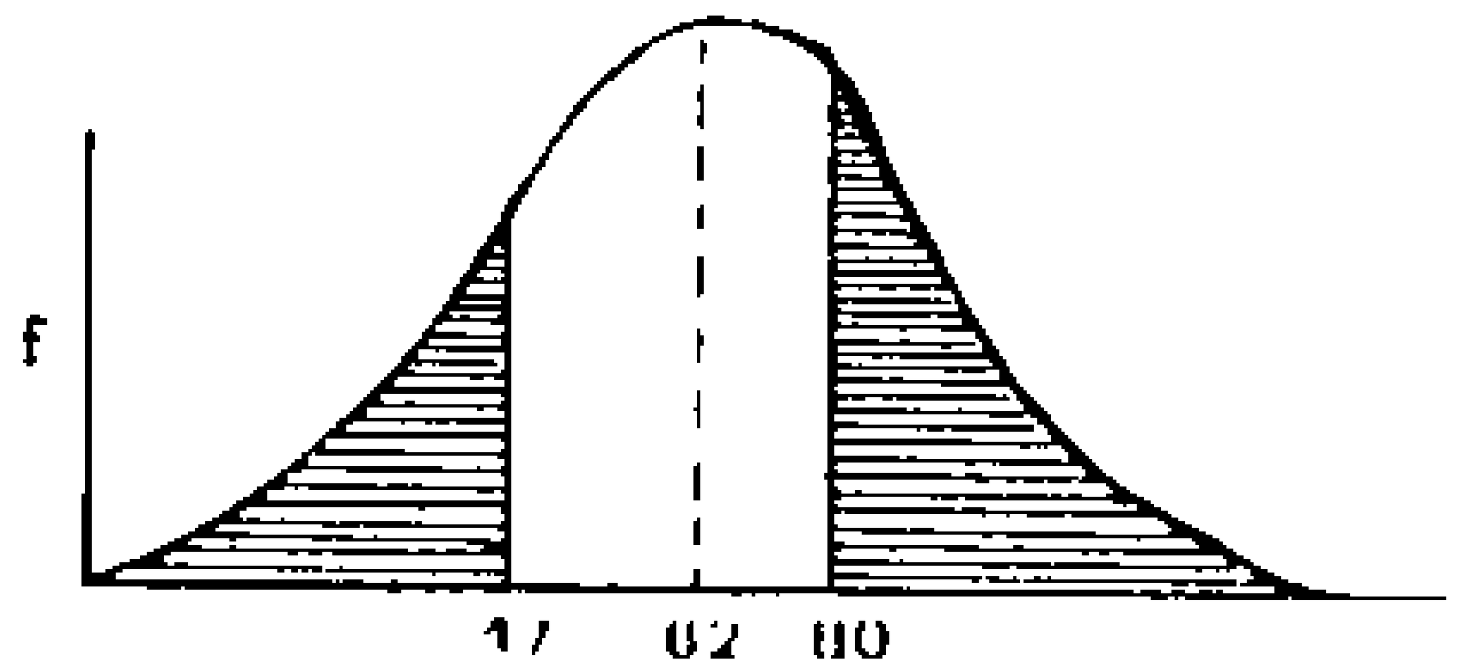
Enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
3	3	
$\boxed{\times}$	3	

KEY ENTRY	DISPLAY	EXPLANATION
52	52	
$\boxed{\div}$	156	n
6	6	
$\boxed{\times}$	26	
3	3	
$\boxed{\div}$	78	
100	100	
$\boxed{=}$	0.78	np
$\boxed{+/-}$	-0.78	
$\boxed{F}$ e^x	0.458406011	

The probability for one device not to fail before 3 years is 0.458.

14. Gaussian Distribution



xmg/100ml (sugar concentration)

Calculate proportions of a normal distribution of sucrose concentrations, where μ = 62 mg/100ml and σ = 21 mg/100ml.

a) What proportion of the population is greater than 80mg/100ml?

b) What proportion of the population is less than 47mg/100ml?

c) What proportion lies inbetween 47mg/100ml and 80mg/100ml?

a) Solution:

We have to find z and then find p $P(x_i > 80mg/100ml) = P(z > \quad)$ using the gaussian distribution.

$$z = \frac{x_i - \mu}{\sigma}$$

Enter as follows:

KEY ENTRY	DISPLAY
80	80
$\boxed{-}$	80
62	62
$\boxed{\div}$	18
21	21
$\boxed{=}$	0.857142857
$\boxed{F}$ GAUSS	0.80431703
+/-	-0.80431703
$\boxed{+}$	-0.80431703
1	1
$\boxed{=}$	0.195682969
STO_n 1	0.195682969

The proportion of the population greater than 80mg/100ml is 0,196.

b) Solution:

to find the proportion that lies less than 47 mg/100 ml, enter as follows: i.e. $P(x_i < 47$ mg/100 ml)

KEY ENTRY	DISPLAY
47	47
[−]	47
62	62
[÷]	−15
21	21
[=]	-0.714285714
[F] GAUSS	0.237525262

The proportion of the population less than 47 mg/100 ml is 0.238.

c) Solution:

to find the proportion that lies between 47 mg/100 ml and 80 mg/100 ml)

P(47 mg/100 ml $< x <$ 80 mg/100 ml) = 1 - P($x_i >$ 80 mg/100 ml) - P($x_i <$ 47 mg/100 ml)

Enter as follows:

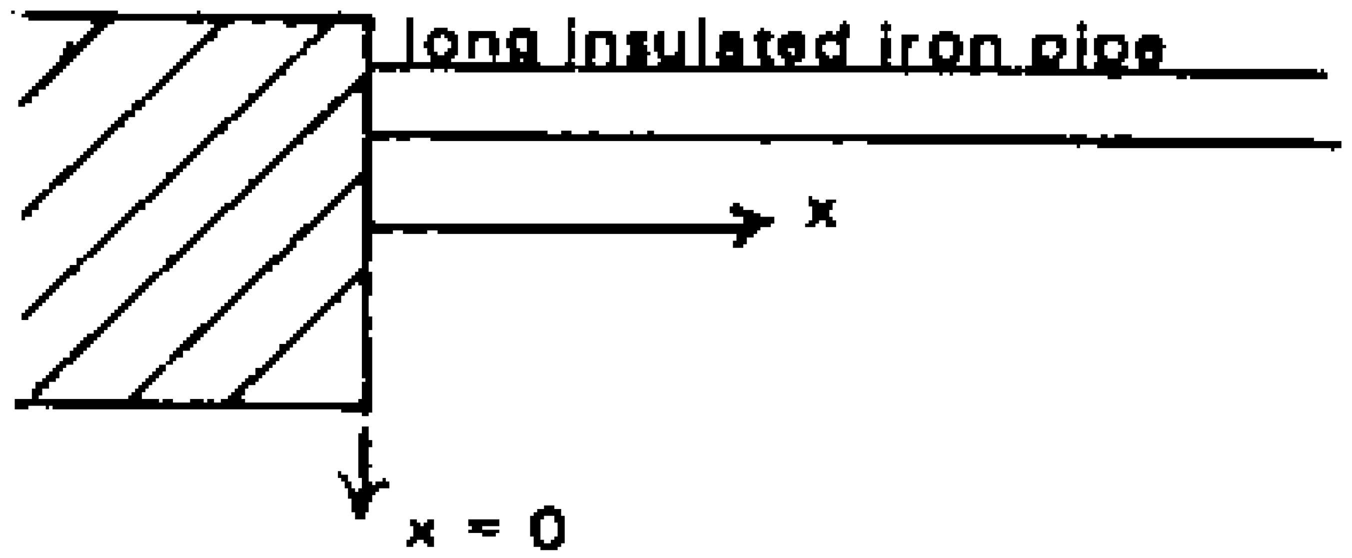
KEY ENTRY	DISPLAY	EXPLANATION
0.237525262	0.237525262	result from (b)
[+Mn] 1	0.237525262	
1	1	

KEY ENTRY	DISPLAY	EXPLANATION
[−]	1	
[RMn] 1	0.433208231	
[=]	0.566791768	

Therefore, the proportion that lies between 47 mg/100 ml and 80 mg/100 ml is 0.567.

15. Error Function on Heat Conduction Using Gaussion Distribution

A very long insulated iron pipe at -40°C is heated to 100°C at one end so that a constant temperature is maintained at that end. Find the temperature 3 meters from the heated end after 15 hours.



The unknown temperature is a function θ of distance "x" and time "t".

The initial conditions are:

(1) at time t = O, θ(x,O) = 40°C

(2) at distance x = O, θ(o,t) = 100° for $t > 0$

(3) in general, $\theta(x,t) = (100 - Ti) \times \left\{1 - \text{erf}\left[\frac{x}{2a\sqrt{t}}\right]\right\} + Ti$ wher Ti is the initial temperature.

Since $\text{erf}(z) = 2\Phi(z\sqrt{2}) - 1$, we can use the Gaussian distribution function to find $\theta(x,t)$ for x = 3 meters and t = 15 hours. Using the relationship and transforming the data, we obtain:

$$\theta(x,t) = 2(100 - Ti)\left[1 - \Phi\left(\frac{x}{a\sqrt{2t}}\right)\right] + Ti$$

Data: $a = 4.71 \times 10^{-3}$ m/ $\sqrt{sec}$ for iron

Ti = -40°C

x = 3 meters

t = 15 hours

Enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
15 [X]	15	
60	60	
[X]	900	
60	60	
[X]	54000	t in seconds
2	2	
[=]	108000	
[F] $\sqrt{X}$	328.6335345	
[X]	328.6335345	
.477 [EE] 2 [+/-]	.477 -02	a for iron in $m/\sqrt{sec}$
[=]	1.56768196	
[1/X]	0.637925177	
[X] 3	3	

KEY ENTRY	DISPLAY	EXPLANATION
[=]	1.913775533	
[F] GAUSS	0.972175578	
[+/-]	-0.972175578	
[+] 1	1	
[X] 2	2	
X	5.564884308-02	
[(((]	5.564884308-02	
100 [+]	100	
40	40	
[)))]	140	
[=]	7.790838031	
[-] 40	40	
[=]	32.20916197	

Answer Temperature = - -32.20916197

16. Using the Exchange Key [x⟷y]

Find $3^{\ln 2 + \sin 30}$

KEY ENTRY	DISPLAY
2	2
[ln]	0.69314718
[+]	
30	30
[sin]	0.5

KEY ENTRY	DISPLAY
[=]	1.193147181
[y^x]	1.193147181
3	3
[x ↔ y]	1.193147181

$\therefore 3^{\ln 2 + \sin 30} = 3.709162666$

17. **Using $\ln\Gamma(x)$ [natural log of gamma function] to find 120!**

Solution: By using the relationship $n! = \Gamma(n + 1)$, we can find

$\Gamma(121)$ to give 120!

$[\ln\Gamma(121) - 10^{99}\ln - 10^{50}\ln]$

KEY ENTRY	DISPLAY	EXPLANATION
121	121	
[F] $\ln\Gamma(x)$	457.812388	
[−]	457.812388	
1 [EE] 99	1. 99	
[ln]	227.9559242	
[=]	229,8564638	By trial & error find that it is over-loaded
[−]	229.8564638	
1 [EE] 50	1. 50	
[ln]	115.1292547	
[=]	114.7272091	

KEY ENTRY DISPLAY EXPLANATION

[F] [e^x]	6.68950291 49

$\therefore 120! = 6.6895 \times 10^{49} \times 10^{99} \times 10^{50}$

$= 6.69 \times 10^{198}$

18: **Solving defenite integral of $\sin^4 u$ using Gamma function**

Solve: $\int_0^{\pi/2} \sin^4 u \, du$

We can solve the problem by the use of the following relationship:

$$\int_0^{\pi/2} \sin^n u \, du = \frac{\sqrt{\pi}}{2} \frac{\Gamma\left(\frac{n-1}{2}\right)}{\Gamma\left(\frac{n+2}{2}\right)} \qquad n > -1$$

in this case $n = 4$

$$\int_0^{\pi/2} \sin^4 u \, du = \frac{\sqrt{\pi}}{2} \frac{\Gamma(1.5)}{\Gamma(3)}$$

Enter as follows:

KEY ENTRY	DISPLAY	EXPLANATION
3	3	
[F] $\ln\Gamma(x)$	0.69314718	
[F] e^x	2	
[1/x]	0.5	
[×]	0.5	
[F] π	3.141592654	
[F] [$\sqrt{x}$]	1.772453851	
[÷]	0.886226	
2	2	
[=]	0.443113462	
[STO_n] 1	0.443113462	

KEY ENTRY	DISPLAY	EXPLANATION
1.5	1.5	
$\boxed{F}$ $\ln\Gamma(x)$	-0.120782237	
$\boxed{F}$ e^x	0.886226925	
$\boxed{\times}$	0.886226925	
$\boxed{RMn}$ 1	0.443113462	
$\boxed{=}$	0.392699081	

$$\int_0^{\pi/2} \sin^4 u \, du = 0.393$$

19. Linear Regression Example

The frequency of electrical impuses emitted is measured from fish at different temperatures. Find the slope and intercept relating impulse frequency to temperature. Also, predict the impulse frequency if the temperature of the fish is 15°C.

The following data is provided:

TEMPERATURE (°C), X	IMPULSE FREQUENCY (number/sec), Y
20	222
22	254
23	274
25	292
27	309
28	314
30	328

Solution:

Enter as follows:

KEY ENTRY	DISPLAY
20	20
$\boxed{x_i}$	20
222	222
$\boxed{y_i}$	1
22	22
$\boxed{x_i}$	22
254	254
$\boxed{y_i}$	2
23	23
$\boxed{x_i}$	23
274	274
$\boxed{y_i}$	3
25	25
$\boxed{x_i}$	25
292	292
$\boxed{y_i}$	4
27	27
$\boxed{x_i}$	27
309	309
$\boxed{y_i}$	5
28	28

KEY ENTRY	DISPLAY
$\boxed{x_i}$	28
314	314
$\boxed{y_i}$	6
30	30
$\boxed{x_i}$	30
328	328
$\boxed{y_i}$	7
$\boxed{F}$ Slope	10.26315789
$\boxed{F}$ intcp	28.13533835
15 $\boxed{\hat{y}}$	182.0827068

Therefore, the regression equation is:

$$\hat{y} = 10.263x + 28.135$$

where b = 10.263 impulses/sec/°C
a = 28.135 impulses/sec

The predicted impulse frequency if the temperature is 15°C is 182.08 impulses/sec.

Note: Memory registers must be cleared before entering first datum.

20. Mean and Standard Deviation

A group of 10 experimental animals consists of individuals with the following body weights (in grams): 85.5, 86.5, 82.4, 89.7, 72.2, 78.4, 69.9, 78.9, 77.3, 86.2.

a) Calculate the mean weight of these animals.

b) Find the precision of the measurement (i.e. the unbiased standard deviation).

<u>Solution</u>:

Enter as follows:

KEY ENTRY	DISPLAY
85.5	85.5
$\boxed{x_n}$	85.5
86.5	86.5
$\boxed{x_n}$	86.5
82.4	82.4
$\boxed{x_n}$	82.4
89.7	89.7
$\boxed{x_n}$	89.7
72.2	72.2
$\boxed{x_n}$	72.2
78.4	78.4
$\boxed{x_n}$	78.4
69.9	69.9
$\boxed{x_n}$	69.9

KEY ENTRY	DISPLAY
78.9	78.9
$\boxed{x_n}$	78.9
77.3	77.3
$\boxed{x_n}$	77.3
86.2	86.2
$\boxed{x_n}$	86.2
$\boxed{\bar{x}}$	80.7
$\boxed{F}$ s	6.496152708

a The mean weight of the animals is 80.7 gms.

b The precision of the measurements is 6.50 gms.

APPENDIX A

Error Conditions

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

When an error condition occurs, the word "ERROR" is displayed on the calculator. To clear ERROR from display, depress $\boxed{C/CE}$

Overflow

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

Underflow

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.)
$\boxed{F}$ $\sqrt{x}$		2 counts in D_{10}
$\boxed{ln}$ x		1 count in D_{10}
$\boxed{log}$ x		1 count in D_{10}
$\boxed{F}$ e^x		3 counts in D_{10}
$\boxed{y^x}$		1 count in D_9
$\boxed{sin}$ ϕ	$0 \leq \lvert\phi\rvert \leq 360°$ or $0 \leq \lvert\phi\rvert \leq 2\pi$	8 counts in D_{10}
$\boxed{cos}$ ϕ	$0° \leq \lvert\phi\rvert \leq 360°$ or $0 \leq \lvert\phi\rvert \leq 2\pi$	8 counts in D_{10}
$\boxed{tan}$ ϕ	$0 \leq \lvert\phi\rvert < 89°$ $89° \leq \lvert\phi\rvert \leq 89.95°$	4 counts in D_9 1 count in D_6
$\boxed{F}$ $\sin^{-1}$ x	$10^{-10} \leq \lvert x\rvert \leq$	$E < 5 \times 10^{-8}$
$\boxed{F}$ $\cos^{-1}$ x	$10^{-10} \leq \lvert x\rvert \leq$	$E < 5 \times 10^{-8}$
$\boxed{F}$ $\tan^{-1}$ x		$E < 5 \times 10^{-8}$
Linear regression (alt. linear regression parameters)		5 counts in D_{10}

Appendix C Table 1. Discrete and Continuous Probability Distribution Laws

Name	Parameters	Probability Mass Function	Mean	Variance	Moment Generating Function
		Discrete Probability Distribution			
Binomial	n a positive integer $0 \le p \le 1$	$C_k^n p^k (1-p)^{n-k}$ $k = 0, 1, 2, \ldots, n$	np	$np(1-p)$	$(pe^t + 1 - p)^n$
Poisson	$\lambda > 0$	$\frac{e^{-\lambda}\lambda^k}{k!}$ $k = 0, 1, \cdots$ 0 Otherwise	λ	λ	$e^{\lambda(e^t - 1)}$
Hypergeometric	n, v_1, v_2 positive integers $n \le v_1 + v_2$	$\frac{C_p^{v_1} \; C_{n-p}^{v_2}}{C_n^{v_1+v_2}}$	$\frac{nv_1}{v_1+v_2}$	$\frac{v_1 v_2 n (v_1 + v_2 - n)}{(v_1+v_2)^2 (v_1+v_2-1)}$	$\frac{C_n^{v_1}}{(v_1+v_2)_n} F(-n, -v_1; v_1 - n; e^t)$
		Continuous Probability Distributions			
Normal or Gaussian	$-\infty < \mu < \infty$ $\sigma > 0$	$\frac{1}{\sqrt{2\pi}\sigma} e^{-(x-\mu)^2/2\sigma}$	μ	σ^2	$e^{t\mu + (\sigma^2 t^2/2)}$
Chi Square or X^2	v is a positive integer (degrees of freedom)	$\frac{x^{v-2/2} e^{-x/2}}{2^{v/2} \Gamma(v/2)}$ $x > 0$ 0 Otherwise	v	$2v$	$(1-2t)^{-v/2}$
F or Snedecor's F	and positive integers (degrees of freedom)	$\frac{\Gamma\left(\frac{v_1+v_2}{2}\right)\left(\frac{v_1}{v_2}\right)^{v_1/2} x^{\frac{v_1-2}{2}}}{\Gamma\left(\frac{v_1}{2}\right)\Gamma\left(\frac{v_2}{2}\right)\left(1+\frac{v_1}{v_2}x\right)^{\frac{v_1+v_2}{2}}}$ $x > 0$ 0 Otherwise	$\frac{v_2}{v_2 - 2}, v_2 > 2$	$\frac{2v_2^2 (v_1+v_2-2)}{v_1(v_2-2)^2(v_2-4)}$ $v_2 > 4$	
t or Student's t	positive integer (degrees of freedom)	$\frac{\Gamma\left(\frac{v+1}{2}\right)}{\sqrt{\pi v}\,\Gamma(v/2)(1+x^2/v)^{(v+1)/2}}$	$0, v > 1$	$\frac{v}{v-2}, v > 2$	

Function	Input Argument	Mantissa Error (Max.)
Mean and Standard Deviation		5 counts in D_{10}
Combination & Permutation, Binomial, Poisson and Gaussian Distributions	n,m positive integers ($n \geq m$)	1 count in D_9
n!	$n < 69$	6 counts in D_{10}
ln $\Gamma(x)$	Positive	6 counts in D_{10}
Cosh y		
Sinh y		1 count in D_{10}
tanh y		
$\text{Cosh}^{-1}y$		6 counts in D_{10}
$\text{Sinh}^{-1}y$		
$\text{tanh}^{-1}y$		
Complex arithmetic		1 count in D_{10}
Δ% %		1 count in D_{10}

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

APPENDIX D.

Useful Formulas and Topics

Hyperbolic Functions

$\cosh u \pm \sinh u = e^{\pm u}$
$\cosh^2 u - \sinh^2 u = 1$

$\sinh(a + jb) = \sinh a.\cos b + j(\cosh a.\sin b)$

$\cosh(a + jb) = \cosh a.\cos b + j(\sinh a.\sin b)$

hyperbolic $(jb) = j$ trigonometric (b)

$$\text{Arc tanh}(a + jb) = \frac{1}{2}\text{Arc tanh}\frac{2a}{1 + a^2 + b^2} + \frac{j}{2}\text{Arc tan}\frac{2b}{1 - a^2 - b^2}$$

Factorial of Even Numbers

$(2n)!! = 2.4.6......2n = 2^n\, n!$

Factorial of odd Numbers

$$(2n - 1)!! = 1.3.5......(2n-1) = \frac{1}{\sqrt{\pi}}\, 2^n\, \Gamma\left(n + \frac{1}{2}\right)$$

Gamma and Beta Functions

$\Gamma(n + 1) = n\,\Gamma(n) = n!$

$$B(x,y) = \frac{\Gamma(x)\,\Gamma(y)}{\Gamma(x + y)}$$

Error Function

$$E\,rf(x) = \int_0^x e^{-t^2}\,dt = 2\,\Phi(x\sqrt{2}) - 1$$

Binomial Coefficients

$$(1 + x)^n = \sum_{r=0}^{n} C_r^n x^r \quad n > o$$

Combinations with Repetitions

The number of ways in which r indistinguishable particles can be distributed among n cells with no restrictions as to the number of particles permitted in any one cell is

in any one cell si: $C_r^{n + r - 1}$

Multinomial coefficients

The number of ways in which a set of r elements can be partitioned into an ordered set of k subjects having $r_1, r_2 .... r_k$ elements respectively with $\Sigma_1^k r_i = n$ is:

$$\frac{n!}{r_1!\, r_2!\, ... r_k!} = C^n_{r_1} \times C^{n - r_1}_{r_2} \times C^{n - r_1 - r_2}_{r_3} \times .... C^{rk}_{rk}$$

Matching

The number of ways in which n numbered elements can go into n numbered cells so that no element goes into a cell having the same number as the element is:

$$\frac{n!}{2!} - \frac{n!}{3!} + \frac{n!}{4!} \;.......\; \pm\frac{n!}{n!} = (-1)^n\,(1 - P_1^n + P_2^n - P_3^n + ... + (-1)^n P^n_{n-2}$$

Negative Binomial Distribution

The probability of getting an mth success on the nth trial, each success having the probability p, is:

$C^{n-1}_{m-1} \times p^m \times (1 - p)^n$

Hypergeometric Distribution (Sampling Without Replacement)

The probability of getting m success out of n trials out of a set containing a successes and b failures, each with an equal probability of being selected is:

$$\frac{C^a_m \times C^b_{n-m}}{C^{a+b}_n}$$

Useful Definite Integrals

$$\int_0^{\infty} \frac{\cosh 2yt}{(\cosh t)^{2x}} dt = 2^{2x-2} \frac{\Gamma(x+y)\,\Gamma(x-y)}{\Gamma(2x)}$$

Real x $>$ 0 Real x $>$/ Real y

$$\int_0^{\pi/2} \cos^h \theta d\theta = \int_0^{\pi/2} \sin \theta d\theta = \frac{\sqrt{\pi}}{2} \frac{\Gamma\left(\frac{n+1}{2}\right)}{\Gamma\left(\frac{n+2}{2}\right)}$$

Real n > -1

$$\int_0^{\pi/2} \cos^m \theta \sin^n \theta d\theta = \frac{1}{2} \frac{\Gamma\left(\frac{m+1}{2}\right)\Gamma\left(\frac{n+1}{2}\right)}{\Gamma\left(\frac{m+n+2}{2}\right)}$$

$$\int_0^{\infty} \frac{a\,dx}{a^2+x^2} = \frac{\pi}{2} \text{ if } a > 0; = 0 \text{ if } a = 0; = \frac{\pi}{2},$$

if a $<$ 0

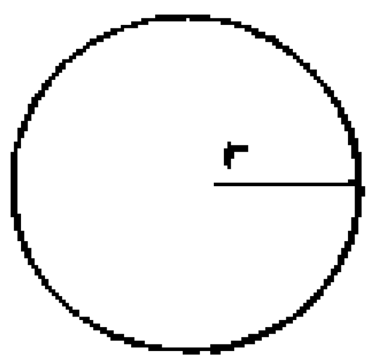
$$\int_0^{\infty} e^{-nx} \sqrt{x}\, dx = \frac{1}{2n} \sqrt{\frac{\pi}{n}}$$

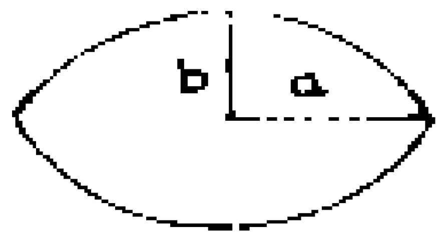
$$\int_0 \frac{\ln x}{1-x} dx = -\frac{\pi^2}{6}$$

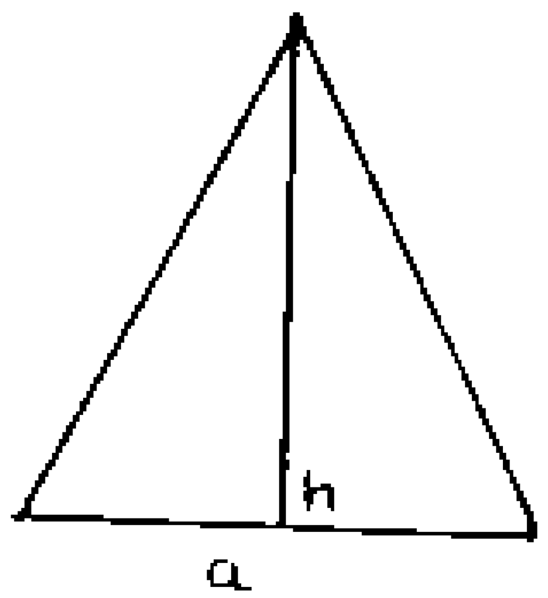
$$\int_0^1 \frac{\ln x}{1+x} dx = -\frac{\pi^2}{12}$$

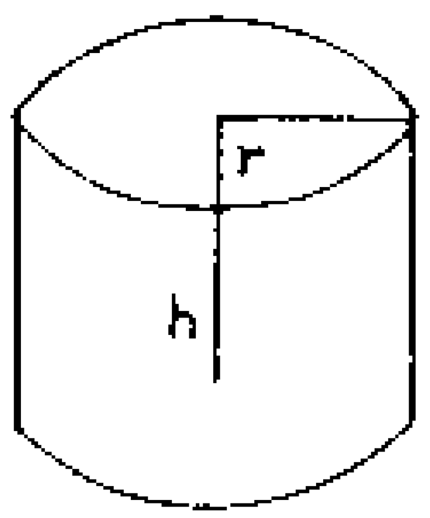
$$\int_0^1 (\ln x)^n dx = (-1)^n \cdot n!$$

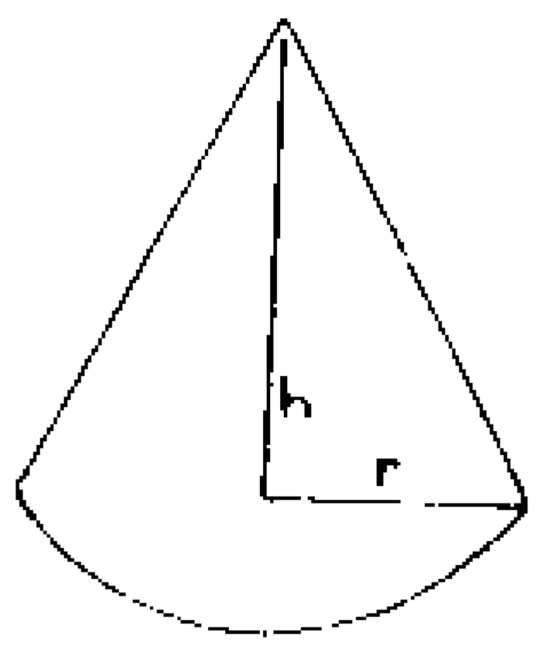
Geometric Formulas











1. **Circumference:**

Circle $2\pi r$

2. **Area:**

Circle πr^2

Ellipse πab

Sphere $4\pi r^2$

Cylinder $2\pi r^2 + 2\pi rh(r+h)$

Triangle ½ ah

3. **Volume:**

Ellipsoid of Revolution $4/3\, b^2 a$

Spere $4/3\, \pi r^3$

Cylinder $\pi r^2 h$

Cone $\frac{\pi r^2 h}{3}$

II LINEAR REGRESSION

The simple linear regression equation is given as:

$$y_i = \alpha + \beta x_i$$

let a, b be the estimates of α and β respectively.

$$\Sigma xy = (x_i - \bar{x})(y_i - \bar{y}) = \Sigma x_i y_i - \frac{(\Sigma x_i)(\Sigma y_i)}{N}$$

$$\Sigma x^2 = \Sigma(x_i - \bar{x})^2 = \Sigma x_i^2 - (\Sigma x_i)^2/N =$$

$$\Sigma y^2 = \Sigma(y_i - \bar{y}) = \Sigma y^2 - (\Sigma y_i)^2/N = \text{Total SS}$$

1) $\hat{b}$ slope $= \frac{\Sigma xy}{\Sigma x^2} = \frac{\Sigma x_i y_i - \frac{(\Sigma x_i)(\Sigma y_i)}{N}}{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{N}}$

2) intercept a

$a = \bar{y} - b\bar{x}$ where $\bar{x} = \frac{\Sigma x_i}{N}$ and $\bar{y} = \frac{\Sigma y_i}{N}$

3) coefficient of determination r^2

$$r^2 = \frac{\left[\Sigma x_i y_i - \frac{\Sigma x_i y_i}{N}\right]^2}{\left[\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{N}\right]\left[\Sigma y_i^2 - \frac{(\Sigma y_i)^2}{N}\right]} = \frac{(\Sigma xy)^2}{(\Sigma x^2)(\Sigma y^2)}$$

4) estimated value $\hat{y}$ on the regression line for any given x

$\hat{y} = a + bx$

5) Regression SS $= \frac{(\Sigma xy)^2}{\Sigma x^2} = \frac{\Sigma x_i y_i - \frac{(\Sigma x_i)(\Sigma y_i)}{N}}{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{N}}$

6) RSS = TSS-RegSS $= \Sigma(y_i - \hat{y})^2$

7) standard error of estimate of y on x

$$S_{y.x} = \frac{\Sigma(y_i - \hat{y})^2}{N-2} = \sqrt{\frac{RSS}{N-2}}$$

8) standard error of the regression coefficient, a (the intercept)

$$S_{\bar{a}} = S_{y.x}\sqrt{\frac{\Sigma x_i^2}{N\,\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{N}}} = \sqrt{s^2_{y.x}\left[\frac{\Sigma x_i^2}{N\Sigma x^2}\right]}$$

9) standard error of slope, b

$$S_{\bar{b}} = \frac{S_{y.x}}{\sqrt{\Sigma x_i^2 - \frac{\Sigma(x_i)^2}{N}}}$$

10) Linear Regression Mean Square

$\frac{\text{Reg SS}}{\text{Reg df}} = \frac{\text{Reg SS}}{1}$

11) Residual Mean Square $= \frac{\text{RSS}}{\text{Residual df}}$

$\frac{\text{RSS}}{N-2} = s^2_{y.x}$

12) To test for Ho $\beta = 0$, HA $\beta \neq 0$ $\quad F = \frac{\text{MS regression}}{\text{MS residual}}$

which is compared with the critical value, $F_{\alpha}\, v_1, v_2$ where v_1 = df regression = 1 and v_2 = df residual = N-2

13) standard deviation of the x values

$$S_x = \frac{\Sigma x_i^2 - N\bar{x}^2}{N-1}$$

14) standard deviation of the y values

$$S_y = \frac{\Sigma y_i^2 - N\bar{y}^2}{N-1}$$

APPENDIX E

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

Symbol Given		Multiply by	To Obtain	Symbol
LENGTH				
mi	miles (statute)	1.609	kilometers	km
nmi	miles (Nautical)	1.852*	kilometers	km
	micron	1.0*	micrometers	um
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 (10^4m^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 centi-meters	cm^3
ft^3	cubic feet	0.02832	cubic meters	m^3

Symbol Given		Multiply by	To Obtain	Symbol
LENGTH				
yd^3	cubic yard	0.7646	cubic meters	m^3
bbl	barrels (US petrol) petrol)	0.1590	cubic meters	m^3
	acre feet	1233.5	cubic meters	m^3
SPEED				
ft/min	feet feet per minute	5.080	millimeters per second	mm/s
mi/h	miles per hour	0.4470	meters per	m/s
km/h	kilo-meters 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
FORCE				
oz.	ounces-force	0.2780	newtons	N
lb.	pounds-force	4.448	newtons	N

Symbol Given		Multiply by	To Obtain	Symbol
LENGTH				
kg.	kilo-grams force	9.807	newtons	N
dyn	dynes	10^5	newtons	N
WORK, ENERGY- POWER				
ft lb	foot pounds force	1.356	joules	J
cal	calorie (thermo chem)	4.184 *	joules	J
Btu	British thermal units(Intl)	1055	joules	J
hp	horsepower (elec)	746 *	watts	W
ft lbs/s	foot pounds force per second	1.356	watts	W
Btu/h	British thermal units per hour(Lntl)	0.2931	watts	W
PRESSURE				
lb/in^2	pounds-force/ $inch^2$	6.895	kilopascals	kPa
lb/ft^2	pounds-force/ $foot^2$	47.88	pascals	Pa
kg/m^2	kilo-grams-force/ $meter^2$	9.807	pascals	Pa
mb	millibars	100.0*	pascals	Pa

Symbol Given		Multiply by	To Obtain	Symbol
LENGTH				
mm Hg	milli meters of Hg	133.3	pascals	Pa
m H_2O	inches of water (39)	0.2491	kilopascals	kPa
m H_2O	feet of water	2.989	kilopascals	kPa
LIGHT				
fc	footcandles	10.76	lux	lx
fL	footlambers	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)5/9	Celsius	°C
°C	Celsius	$°C\frac{9}{5} + 32$	Fehrenheit	°F

*Indicates exact value 5 omit when rounding

Symbols for Quantities

Quantity	Qty. Symbol	SI Unit	Unit Symbol	Identical Unit
length	l	meter	m	
mass	m	kilogram	kg	
time	t	second	s	
frequency	f, ν	hertz	Hz	i/s
angular frequency	w	radian per sec	rad/s	
area	A,,S	sq. meter	m^2	
volume	V	cubic meter	m^3	

Quantity	Qty. Symbol	SI Unit	Unit Symbol	Identical Unit
velocity	v	meter per second	m/s	
acceleration (linear)	a	meter per sec^2	m/s^2	
force	F	newton	N	
torque	T,.M	newton meter	N·m	
pressure	P	pascal	Pa	N/m^2
temperature (absolute)	T...O	kelvin	K	
temperature (customary)	t,.o	degree Celsius	°C	
attenuation coefficient	α	neper per mtr	Np/m	
phase coefficient	β	radian per meter	rad/m	
propagation coefficient ($\gamma = \alpha + j\beta$)	γ	reciprocal meter	m^{-1}	
radiant intensity	/	watt per steradian	W/sr	
radiant flux	Pϕ	watt	W	
irradiance	E	watt per sq. meter	W/m^2	
luminous intensity	/	candela	cd	
luminous flux	ϕ	lumen	lm	
Illuminance	E	lux	lx	lm/m^2

YSICAL CONSTANTS

tronic charge	e.	$1.602 \times 10^{-19} C$
eed of light in vacuum, ...	c.	$2.9979 \times 10^{8} m/s$
mittivity of vacuum, elec ost	ε_0	8.854×10^{-12} F/m
meability of vacuum, mag ost.	μ_0	$4^{\pi} \times 10^{-7}$ H/m
anck constant	h.	6.626×10^{-34} J·s
oltzmann constant	k	1.38×10^{-23} J/K
araday constant	F	9.649×10^{4} C/mo
andard gravitational celeration	g	$9.807 m/s^2$
ormal atmospheric pressure	atm	101.3 kPa

ACTOR
JNIT PREFIX
YMBOL

10^{12}	tera	T	10^{1}	deka	dal	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

APPENDIX F

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 to "ON". 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.

IMPORTANT -- Low Power

If battery is low
a. Display will appear erratic
b. Display will dim
c. Display will fail to accept numbers
If one or all of the above condition 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°

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

Adapter 640 or 707 North America

Adapter 708 England

Adapter 709 Continental Europe