Commodore Business Machines, Inc.
901 California Avenue
Palo Alto, California 94304, USA

Commodore/MOS Technology
Valley Forge Corporate Center
950 Rittenhouse Road
Norristown, Pennsylvania 19403, USA

Commodore Business Machines Limited
3370 Pharmacy Avenue
Agincourt, Ontario, Canada M1W2K4

Commodore Business Machines (UK) Limited
Eaglescliffe Industrial Estate
Eaglescliffe, Stockton on Tees
Teeside TS 160 PN, England

Commodore Büromaschinen GmbH
Frankfurter Strasse 171-175
6078 Neu Isenburg
West Germany

Commodore Japan Limited
Taisei-Denshi Building
8-14 Ikue 1-Chome
Asahi-Ku, Osaka 535, Japan

Commodore Electronics (Hong Kong) Ltd.
Watson's Estates
Block C, 11th floor
Hong Kong,

commodore

PRINTED IN HONG KONG

for appt on Thurs.
2 Regal Aid

SR4921 RPN

Reverse Notation

Scientific Calculator

Instruction Manual

commodore

Keyboard Index

Introduction

The Commodore SR4921 RPN Scientific calculator offers a wide variety of mathematical and statistical functions and the convenience of "Reverse Polish Notation," all at a very low price.

Reverse Polish Notation allows very complex algebraic statements to be solved with a minimal number of keystrokes. Parentheses are not needed as numbers and operations are simply entered in the order in which they are executed.

The brain of the SR4921, a unique single 3/4" x 1/2" x 1/16" microprocessor chip, designed and produced by MOS Technology (a Commodore company), contains enough circuitry to generate trigonometric, inverse trigonometric, logarithmic; and power and root functions. In addition to the four level RPN operational chain, there are three memories, a percent operator and a rectangular/polar coordinate converter.

The statistical program is particularly useful. Enter a list of numbers and the machine will compute the sample mean $\bar{x}$, the standard deviation s, the sum Σx, and the sum of squares Σx^2.

We recommend that the RPN novice work through this manual step-by-step attempting each problem before checking the given solution. There are additional solved problems to reinforce this process. You will find that RP notation is easy to use and very efficient.

Table of Contents

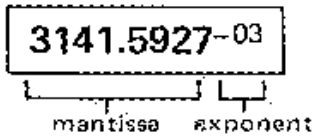
I. Preliminaries

Power On

Your Scientific calculator can run on battery power alone or you can connect to an optional AC adapter. The calculator does not need a battery to run on the adapter.

Slide the ON/OFF switch to the left to turn the calculator on. A red dot will appear to the right of the switch and the display reads 0.

The Display



A sample display is shown above. The number on the display reads

3141.5927×10^{-3} or 3.1415927

Your calculator can compute numbers as large as

99999999×10^{99}

and as infinitesimal as

$.00000001 \times 10^{-99}$

Display Shut-Off Feature

To conserve battery power, the display has a timed shut-off feature. After 60 seconds of non-use, the displayed digits will disappear leaving only the decimal point. No information is lost and the calculations can continue at any time, provided that you have not shut off the calculator. Press [x⇄y] twice to recall the number to the display.

Entry

Enter numbers exactly as they appear using the digit keys and the decimal key [.]. To enter a negative number, press the change sign key [+/-]. The [+/-] key will also change a negative number on the display to a positive one.

Scientific Form

Scientists usually express numbers in the following way:

6.023×10^{23}

This is called *scientific form* and can be easily entered with the following steps.

(1) Enter mantissa, 6.023
(2) If the number is negative, press [+/-]
(3) Enter exponent by pressing [EE] 23
(4) If exponent is negative, press [+/-]

Clearing Entries

If you make a mistake on entry, press [CE] once. This will clear only the display and will leave all other entries undisturbed.

To clear the operational chain, press [INV] [CE].

Error

If you compute a number as big as 10^{100} you will have an overflow condition and an E will appear on the display. Press [CE] to continue.

The Inverse Key [INV]

The inverse key has properties similar to inverse functions in mathematics. As shown on page 17 it is used with the trig keys to calculate the inverse trigonometric functions. On page 19 the [INV] key is used with the polar to rectangular key to convert rectangular to polar coordinates. On page 28, the [INV] key is used with the data entry key [Σn] to delete an entry from an entered sample.

The Pi Key [π]

Press [π] to display pi:

$\pi = 3.1415927$

II. Arithmetic Functions

The RPN Operational Chain

The key to RPN arithmetic operations is **the operational chain**. This is a series of four registers labeled

X Y Z W

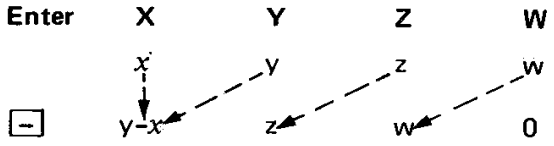
The X register is the display.

The operations +, −, x, ÷ are **binary operations.** That is, they operate on *two* numbers, x and y, to yield a single number:

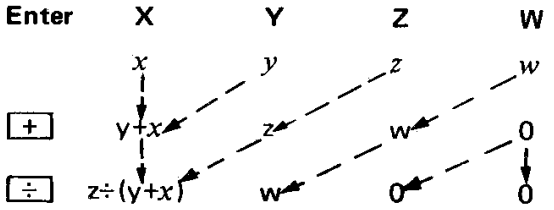
$y + x$ $\quad$ $y - x$
$y \times x$ $\quad$ $y \div x$

Similarly, when one of the keys [+] [−] [x] [÷] is pressed, the operation is performed using the contents of the X and Y registers. The result is placed in the X register and the chain is rotated to the left.

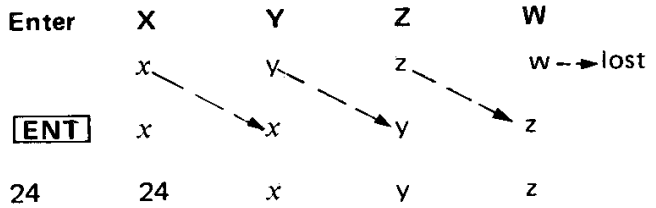
For example, the following illustrates the effect of subtraction on the chain:



Similarly,



The entry key [ENT] is used to enter numbers into the operational chain. Each time you press [ENT] you rotate the chain as shown below. The [ENT] key should be immediately followed by a numerical entry (see note on page 11).



Simple Arithmetic

Example: Find 3.17 x 11.41.

Solution:

Enter	X	Y	Z	W
3.17	3.17			
[ENT]	3.17	3.17		
11.41	11.41	3.17		
[x]	36.170*			

**Note: When using this particular format to represent the operational chain, we will round answers to three significant decimal places, simply to make enough room to make this representation possible. Notice that the above result is actually displayed 36.1697.*

Furthermore, a blank register actually contains the value 0.

Example: Find

3.112 x .621 x 3.195 x 4.003

Solution:

Enter	X	Y	Z	W
3.112	3.112			
[ENT]	3.112	3.112		

Solution Continued

Enter	X	Y	Z	W
.621	.621	3.112		
[ENT]	.621	.621	3.112	
3.195	3.195	.621	3.112	
[ENT]	3.195	3.195	.621	3.112
4.003	4.003	3.195	.621	3.112
[x]	12.790	.621	3.112	
[x]	7.942	3.112		
[x]	24.717			

Practice Problem

Find 11.69 + 41.432 + 9.713 + 14.112

Answer: 76.947

Chaining Arithmetic Operations

When you use more than one of [+] [−] [x] [÷] in a single computation, it is called *chaining.* To calculate an expression with muitiple operations, enter the numbers and operations in the order that they are executed.

Example: Find

$$\frac{3.149}{1.702} - \frac{6.341}{5.712}$$

Solution:

Enter	X	Y	Z	W
3.149	3.149			
[ENT]	3.149	3.149		
1.702	1.702	3.149		
[÷]	1.850			
6.341	6.341	1.850		
[ENT]	6.341	6.341	1.850	
5.712	5.712	6.341	1.850	
[÷]	1.110	1.850		
[−]	0.740			

Example: Find $\dfrac{5-\pi}{1+4/9}$

Solution:

Enter	X	Y	Z	W
5	5			
[ENT]	5	5		
π	3.142	5		
[−]	1.858			
1	1	1.858		
[ENT]	1	1	1.858	
4	4	1	1.858	
[ENT]	4	4	1	1.858
9	9	4	1	1.858
[÷]	.444*	1	1.858	
[+]	1.444	1.858		
[÷]	1.287			

*See note in previous section "Simple Arithmetic".

Practice Problem

Find 9/16 + 7/12 − 11/13

Answer: 0.2996794

The Exchange key [x↔y] will switch the X and Y registers:

Enter	X	Y	Z	W
	x	y	z	w
[x↔y]	y	x	z	w

This key is used in chaining as shown in the next example.

Example:

Find 1/2 − (3/4 − (11/9 − 4/13))

Solution:

11 [ENT] 9 [÷]
4 [ENT] 13 [÷]
[−]
3 [ENT] 4 [÷]
[x↔y] [−]
1 [ENT] 2 [÷]
[x↔y] [−] ⟶ 0.6645299

Practice Problem: Calculate

$$\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1+\pi}}}$$

Answer: 0.5538608

The Rotate key [R↓] is used to rotate the operational chain as shown:

Enter	X	Y	Z	W
	x	y	z	w
[R↓]	y	z	w	x

To rotate the operational chain in the other direction, press [INV] [R↓]:

Enter	X	Y	Z	W
	x	y	z	w
[INV] [R↓]	w	x	y	z

Example: Compute

$$\frac{3.759 - 4.210}{4.773 - 6.482}$$

Solution:

Enter	X	Y	Z	W
3.759 [ENT]	3.759	3.759		
4.210 [ENT]	4.210	4.210	3.759	
4.773 [ENT]	4.773	4.773	4.210	3.759
6.482	6.482	4.773	4.210	3.759
[−]	−1.709	4.210	3.759	
[R↓]	4.210	3.759	0	−1.709
[−]	−0.451	0	−1.709	
[INV] [R↓]	0	−0.451	0	−1.709
[x↔y]	−0.451	0	0	−1.709
[INV] [R↓]	−1.709	−0.451		
[÷]	.264			

Note: Each time you use the [ENT] key, you should immediately follow with a numerical entry. If you rotate the chain or use the exchange key between [ENT] and the numerical entry, you will duplicate an entry as shown:

3 [ENT] [R↓] [R↓] [R↓] [R↓] 4
3 [ENT] [x↔y] [x↔y] 4

Each of the above two programs will enter the following values into the operational chain:

X	Y	Z	W
4	3	3	0

If the [R↓] or [x↔y] keys are not used, the Z entry will be 0.

The Percent Key [%]

Enter	To Display
a [ENT] b [%]	b% of a
a [ENT] b [%] [+]	a + (b% of a)
a [ENT] b [%] [−]	a − (b% of a)

Example: Find

(a) 6¾% of $122.65

(b) increase 533 by 11%

(c) decrease 98.6 by 3.3%

Solution:

122.65 [ENT] 6.75 [%] ⟶ 8.278875

[INV] [CE] (clears the chain)

533 [ENT] 11 [%] [+] ⟶ 591.63

[INV] [CE]

98.6 [ENT] 3.3 [%] [−] ⟶ 95.3462

Rounding off, we get

(a) $8.28

(b) 591.63

(c) 95.3

Example: $20,000 is placed in a savings account which pays 6½% interest each year. How much is the balance at the end of the 5th year?

Solution:

20000 [ENT] 6.5 [%] [+]

6.5 [%] [+]

6.5 [%] [+]

6.5 [%] [+]

6.5 [%] [+] ⟶ 27401.733

The balance will be $27,401.73.

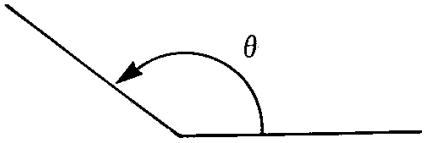
Practice Problem

A $144,000 shrimp boat depreciates by 7.4% each year. What is the value after seven years?

Answer: $84,069.68

III. Trigonometric Operators

The Angle Mode Keys [deg] [rad] [grad]



There are three units for measuring angles

1 circle = 360 degrees

= 2π radians

= 400 gradians

Before using the trig keys, you must put the calculator in the right *angle mode.* That is, you must choose whether you want your entries and answers to be expressed in degrees, radians or gradians.

The machine is naturally operating in degree mode. To change to another mode, press the appropriate key:

[deg] [rad] [grad]

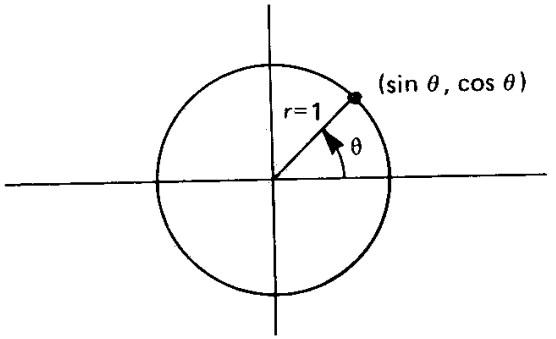
Trigonometric Functions

The functions

$\sin \theta$

$\cos \theta$

are defined by the following diagram

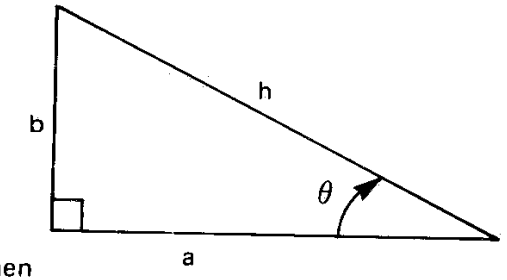


where $(\sin\theta, \cos\theta)$ are the rectangular coordinates of the indicated point on the circle of radius 1 with center (0, 0).

The tangent is defined as

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

The trig functions have the property that if



then

$$\sin\theta = \frac{b}{h} = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos\theta = \frac{a}{h} = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan\theta = \frac{b}{a} = \frac{\text{opposite}}{\text{adjacent}}$$

The Trig Keys [sin] [cos] [tan]

The trig keys [sin] [cos] [tan] instantly compute the sine, cosine and tangent of the angle displayed. Before using the trig keys you should select the appropriate angle mode with the [deg] [rad] or [grad] keys.

Once an angle mode is selected, the calculator will remain in that mode until another angle mode key is used. You do not need to use an angle mode key with every angle entry.

Example: Find

$$\sin 32^\circ - \cos\frac{\pi}{3} + \tan(62\text{ grad})$$

Solution:

32 [sin] [ENT]
π [ENT] 3 [÷]
[rad] [cos] [−]
62 [grad] [tan]
[+] ⟶ 1.5013746

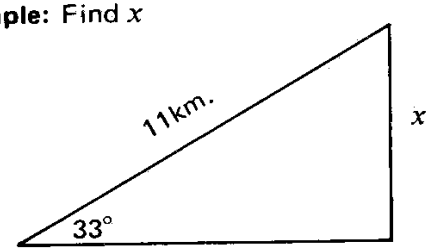
Practice Problem: Find

$$(\tan .97) \times (\cos\frac{\pi}{9} + \sin\frac{4\pi}{11})$$

if all angles are in radians

Answer: 2.6985366

Example: Find x



Solution:

$$\sin 33^\circ = \frac{x}{11\text{ Km}}$$

$$\Rightarrow x = (11 \times \sin 33^\circ)\text{ Km}$$

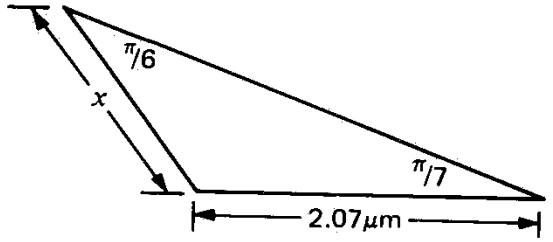
The program is

33 [sin] 11 [x] ⟶ 5.9910294

Therefore,

x = 5.991 Km.

Example: Find x



Solution: Use the law of sines (Appendix F). We have

$$\frac{x}{\sin\frac{\pi}{7}} = \frac{2.07}{\sin\frac{\pi}{6}}$$

$$\Rightarrow x = \frac{2.07}{\sin\frac{\pi}{6}} \times \sin\frac{\pi}{7}$$

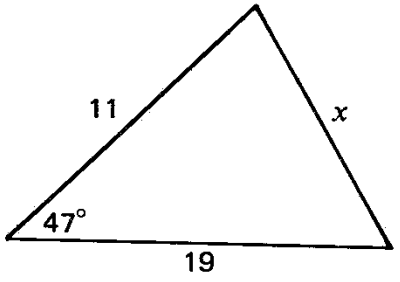
The program is

[rad]
2.07 [ENT]
π [ENT] 6 [÷] [sin]
[÷]
π [ENT] 7 [÷] [sin]
[x] ⟶ 1.7962787

Hence,

$x = 1.796\ \mu m$

Practice Problem: Find x



Answer: $x = 14.032986$

Inverse Trig Functions

The inverse trig functions are the reverse of the trig functions. The trig functions take an angle θ and give you a number x. The inverse trig functions take a number x and give you an angle θ.

The inverse sine, cosine and tangent are denoted

$$\sin^{-1} \qquad \cos^{-1} \qquad \tan^{-1}$$

and are defined by

$$\sin\theta = x \Leftrightarrow \theta = \sin^{-1}x \quad (-180^\circ \leqslant \theta \leqslant 180^\circ)$$
$$\cos\theta = x \Leftrightarrow \theta = \cos^{-1}x \quad (0 \leqslant \theta \leqslant 180^\circ)$$
$$\tan\theta = x \Leftrightarrow \theta = \tan^{-1}x \quad (0 < x)$$

Inverse functions do the reverse operations of their associated functions. We therefore have

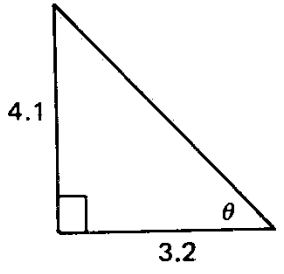
$$\sin^{-1}(\sin\theta) = \theta \qquad \sin(\sin^{-1}x) = x$$
$$\cos^{-1}(\cos\theta) = \theta \qquad \cos(\cos^{-1}x) = x$$
$$\tan^{-1}(\tan\theta) = \theta \qquad \tan(\tan^{-1}x) = x$$

whenever θ and x fall within the above constraints.

To take the inverse sine of the number on display, press [INV] [sin]. The answer is an angle expressed in degrees, radians or gradians as indicated by the angle mode (page 13).

Similarly, to calculate $\cos^{-1}$ and $\tan^{-1}$, press [INV] [cos] and [INV] [tan].

Example: Find θ in gradians



Solution: $\tan\theta = \frac{4.1}{3.2}$

Therefore,

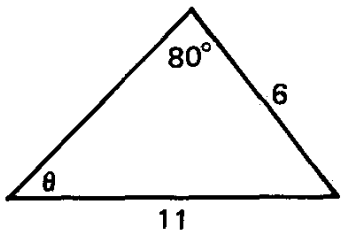
$$\theta = \tan^{-1}\frac{4.1}{3.2}$$

The program is

grad
4.1 ENT 3.2 ÷
INV tan ⟶ 57.809329

So θ = 57.8 gradians.

Practice Problem: Find θ in degrees



Answer: θ = 32.491051

Example: Convert $\frac{\pi}{11}$ radians to degrees.

Solution:

π ENT 11 ÷
rad
sin
deg
INV sin ⟶ 16.363636

Thus

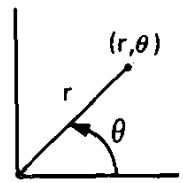
$\frac{\pi}{11}$ radians = 16.4°

Practice Problem: Convert 51.6° into radians.

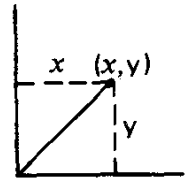
Answer: .2866666 π radians

Polar/Rectangular Coordinates

Polar



Rectangular



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

The above equations show the relationship between polar and rectangular coordinates.

To convert (r, θ) to rectangular coordinates, first enter r ENT θ and then press P→R. This will display x and x↔y will display y. (Remember to put the machine in the appropriate angle mode before using the P→R key.)

To convert (x, y) to polar coordinates, first enter x ENT y and then press INV P→R. This will display r and then x→y will display θ (in the same measure as the angle mode).

Example: Convert to rectangular coordinates

(i) (3, 23°)

(ii) $\left(1, \frac{\pi}{2}\right)$

(iii) (4, 111 grads)

Solution:

3 ENT 23
P→R ⟶ 2.7615146
x↔y ⟶ 1.1721934
rad
1 ENT π ENT 2 ÷
P→R ⟶ 0.
x↔y ⟶ 1.
grad

4 [ENT] 111
[P→R] ⟶ −0.6877164
[x↔y] ⟶ 3.9404373

Therefore, the three points are

(i) (2.76, 1.17)
(ii) (0, 1)
(iii) (−.69, 3.94)

Practice Problem: Convert (1, 7) to polar coordinates.

Answer: (7.0710678, 81.869898°)

IV. Algebraic Operators

[x^2] **Square Key**
Press [x^2] to square the displayed number.

[$\sqrt{x}$] **Square Root Key**
Press [$\sqrt{x}$] to take the square root of the displayed number.

[1/x] **Reciprocal Key**
Press [1/x] for the reciprocal of the displayed number.

Example: Find

$$w = \sqrt{\left(\frac{1}{x}\right)^2 + \left(\frac{1}{y}\right)^2 + \left(\frac{1}{z}\right)^2}$$

where (x, y, z) = (3, 4, 5)

Solution:

3 [1/x] [x^2] [ENT]
4 [1/x] [x^2] [ENT]
5 [1/x] [x^2]
[+] [+]
[$\sqrt{x}$] ⟶ 0.4621808

Practice Problem: Compute

$$\sqrt{\frac{1}{1 + \left(\frac{1}{1+\pi}\right)^2}}$$

Answer: 0.9720658

[y^x] **Power Key**
To find a^b enter
a [ENT] b [y^x]

[$\sqrt[x]{y}$] **Root Key**
To find $\sqrt[b]{a}$ enter
a [ENT] b [$\sqrt[x]{y}$]

Note: With the power and root keys, the base a must be positive.

Example: Find

$$z = \sqrt[41]{(3^{12})^{\pi}}$$

Solution:

3 [ENT] 12 [y^x]
π [y^x]
41 [$\sqrt[x]{y}$] ⟶ 2.7460502

Practice Problem: Compute

$$(\sqrt[\pi]{\pi})^{\cos 16^\circ}$$

Answer: 1.4194414

Properties of Exponents

(i) $\sqrt[b]{a} = a^{\frac{1}{b}}$

(ii) $\frac{1}{a^b} = a^{-b}$

(iii) $a^0 = 1$

(iv) $a^b \times a^c = a^{b+c}$

(v) $\frac{a^b}{a^c} = a^{b-c}$

(vi) $(a^b)^c = a^{bxc}$

Example: Find $\sqrt[7]{-4}$

Solution: You cannot use the $\boxed{y^x}$ and $\boxed{\sqrt[x]{y}}$ keys for negative bases. You must first rearrange this expression using the above identities.

$$\sqrt[7]{-4} = (-4)^{\frac{1}{7}} = (-1 \times 4)^{\frac{1}{7}}$$
$$= (-1)^{\frac{1}{7}} \times 4^{\frac{1}{7}} = \sqrt[7]{-1} \times \sqrt[7]{4}$$
$$= -\sqrt[7]{4}$$

Thus, we compute $-\sqrt[7]{4}$

4 [ENT] 7 $\boxed{\sqrt[x]{y}}$ [+/−] ⟶ −1.2190137

V. Transcendental Operators

[ln] **Natural Logarithm Key**
This key computes the natural log (ln) of the displayed number.

$\boxed{e^x}$ **Natural Antilogarithm Key**
This key computes e^x for a displayed number x.

[log] **Logarithm Key**
This key computes the log to the base 10 of the displayed number.

$\boxed{10^x}$ **Antilogarithm Key**
This key computes the antilog of the displayed number.

Properties of Transcendental Functions

(i) $\ln a + \ln b = \ln (a \times b)$

(ii) $\ln a - \ln b = \ln (a \div b)$

(iii) $b \ln a = \ln (a^b)$

(iv) $e^{\ln x} = x$

(v) $\ln e^x = x$

(vi) $\log a + \log b = \log (a \times b)$

(vii) $\log a - \log b = \log (a \div b)$

(viii) $b \log a = \log (a^b)$

(ix) $10^{\log x} = x$

(x) $\log 10^x = x$

Example: A colony of bacteria has the following population formula

$$n = 3.6 \times 10^{2t} + 4.9 \times 10^4$$

Here, the number of organisms, n is determined by the number of days, t. How long will it take the population to reach 100 million?

Solution: Solve for t:

$$3.6 \times 10^{2t} + 4.9 \times 10^4 = 10^8$$
$$\Rightarrow 3.6 \times 10^{2t} = 10^8 - (4.9 \times 10^4)$$
$$\Rightarrow 10^{2t} = \frac{10^8 - (4.9 \times 10^4)}{3.6}$$

Take the log of both sides:

$$\log 10^{2t} = \log \left(\frac{10^8 - (4.9 \times 10^4)}{3.6}\right)$$

By property (ix) above,

$$\log 10^{2t} = 2t$$

Thus,

$$t = \frac{1}{2} \log \left(\frac{10^8 - (4.9 \times 10^4)}{3.6}\right)$$

Now, compute t

1 [EE] 8 [ENT]
4.9 [EE] 4 [−]
3.6 [÷]
[log]
2 [÷] ⟶ 3.7217423
3 [−] 24 [x] ⟶ 17.321816

Thus, it will take approximately 3 days and 17 hours to reach a population of 100 million.

Practice Problem: Calculate

$$e^{\pi} + e^{\pi}$$

Answer: 2.5956819×10^{11}

VI. Memories

There are three memories labeled

0, 1, 2

Operations for the n memory (n = 0, 1, 2) are made with the following keys:

STO **Store Key**
To store the displayed number in memory n, press STO n. This will override the previous entry in memory n.

RCL **Recall Key**
Press RCL n to display the contents of memory n.

M+ **Add to Memory**
Press M+ n to add the displayed number to the number stored in memory n. The sum is then stored in memory n.

Mx **Multiply by Memory**
Press Mx n to multiply the displayed number by the number stored in memory n. The product is then stored in memory n.

XCH **Memory Exchange**
To display the contents of memory n and at the same time store the displayed number in memory n, simply press XCH n.

Note: Each time a memory key is used, it must be immediately followed by 0, 1, or 2 to indicate which memory is used.

Note: After recalling a number from memory, you do not need to press ENT to enter the number to the operational chain. For example, if 19 is in memory 2, RCL 2 37 will put 19 into register y and 37 into register x.

Example: Find

$$\frac{e^x - e^{-x}}{e^x + e^{-x}} \text{ if } x = \sqrt{\frac{1}{\sin^2 19^\circ} + \frac{1}{\cos^2 19^\circ}}$$

Solution:

19 sin x^2 1/x
19 cos x^2 1/x
+
$\sqrt{x}$
STO 0
e^x RCL 0 +/− e^x −
RCL 0 e^x
RCL 0 +/− e^x
+ ÷ ⟶ .9969888

Practice Problem: Compute

$$3x^4 + 2x^2 - 6x + 1$$

where

$$x = \sqrt{\tan 31^\circ + \pi}$$

Answer: 38.895523

Example: Find x if

$$3x^2 - 5x + 1 = 0$$

Solution: Use the quadratic formula (Appendix F)

$$x = \frac{-(-5) \pm \sqrt{(-5)^2 - (4)(3)(1)}}{(2)(3)}$$

The program is

5 x^2 4 ENT 3
× − $\sqrt{x}$
STO 0

5 [+]
2 [ENT] 3
[x] [÷] ⟶ 1.4342585
5 [RCL] 0 [−]
2 [ENT] 3
[x] [÷] ⟶ 0.2324081

Practice Problem: Find x

$$x^4 - 1.9x^2 + .84 = 0$$

Answer: $x = \begin{cases} \pm\ 0.83666 \\ \pm\ 1.0954451 \end{cases}$

Example: Compute

$$\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\frac{1}{5!}+\frac{1}{6!}$$

Solution:

1 [STO] 0 [STO] 1
2 [Mx] 0
[RCL] 0 [1/x] [M+] 1
3 [Mx] 0
[RCL] 0 [1/x] [M+] 1
4 [Mx] 0
[RCL] 0 [1/x] [M+] 1
5 [Mx] 0
[RCL] 0 [1/x] [M+] 1
6 [Mx] 1
[RCL] 0 [1/x] [M+] 0
[RCL] 1 ⟶ 1.7180556

Practice Problem: Compute

$$\frac{11!}{8!\,3!}$$

Answer: 165

Example: Find the determinant of the following matrix

$$A = \begin{bmatrix} 3.1 & 6.2 & 4.8 \\ 1.7 & 3.3 & 11.1 \\ 1.4 & 3.5 & 5.7 \end{bmatrix}$$

Solution:

3.1 [ENT] 3.3 [ENT] 5.7 [x]
11.1 [ENT] 3.5
[x] [−] [x] [STO] 0
6.2 [ENT] 1.7 [ENT] 5.7 [x]
1.4 [ENT] 11.1
[x] [−] [x] [STO] 1
4.8 [ENT] 1.7 [ENT] 3.5 [x]
1.4 [ENT] 3.3
[x] [−] [x] [STO] 2
[RCL] 0 [RCL] 1 [RCL] 2
[x↔y] [−] [+] ⟶ −19.47

VII. Statistical Operators

Given a sample of observed values

$$x_1, x_2, \ldots, x_n$$

the calculator will evaluate the **sample mean**:

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

the **standard deviations**

$$s = \sqrt{\frac{\Sigma (x_i - \bar{x})^2}{n-1}}$$

$$s' = \sqrt{\frac{\Sigma (x_i - \bar{x})^2}{n}}$$

the **sum of entries**

$$\Sigma x_i$$

and the **sum of squares**

$$\Sigma x_i^2$$

Appendix A contains useful statistical tests. The Normal distribution is in Appendix B and the Student's distribution is in Appendix C.

The Statistical Keys

$[x_n]$ **Data Entry:** To enter a sample 5, 9, 11, 21 press 5 $[x_n]$ 9 $[x_n]$ 11 $[x_n]$ 21 $[x_n]$. To delete 11 from this sample press 11 [INV] $[x_n]$. Each time $[x_n]$ is pressed, the number of points entered so far is displayed.

$[\bar{x}]$ **Sample Mean:** Press $[\bar{x}]$ for the sample mean once the data has been entered.

[s] [s'] **Standard Deviation:** Press [s] or [s'] for the unbiased and biased standard deviations as defined above.

n **Number of Entries:** The number of points entered, n, is stored in memory 0.

Σx_i **Sum of Entries:** The sum of entries is stored in memory 1.

Σx_i^2 **Sum of Squares:** The sum of squares is stored in memory 2.

Important: Memories cannot be used during statistical computations. Before beginning statistical computations, all three memories must be cleared by switching the machine off and on or by entering 0 into all three memories.

Confidence Intervals

Example: A new laboratory technique to synthesize a rare chemical compound has resulted in the following yields in grams.

0.47	0.44	0.62
0.51	0.53	0.50
0.69	0.49	0.55

Find the 95% confidence interval for the average yield for the new process.

Solution: First, find $\bar{x}$ and s_x

.47 $[x_n]$ .44 $[x_n]$ .62 $[x_n]$
.51 $[x_n]$ .53 $[x_n]$ .50 $[x_n]$
.69 $[x_n]$ .49 $[x_n]$ .55 $[x_n]$

$[\bar{x}]$ $\longrightarrow$ 0.5333333

[s] $\longrightarrow$ 7.7942286^{-02}

By test 3, Appendix A, the value

$$t = \frac{\bar{x} - m_{\bar{x}}}{s_{\bar{x}}}$$

satisfies a t distribution with 8 degrees of freedom where

$$m_{\bar{x}} = m_x$$

$$s_{\bar{x}} = \frac{s_x}{\sqrt{n}}$$

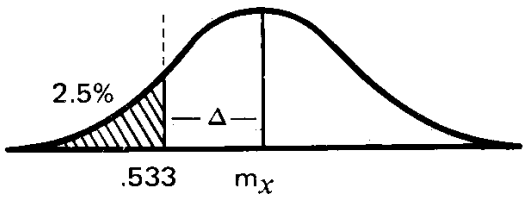
$$= \frac{7.7942286 \times 10^{-2}}{\sqrt{9}}$$

$$= 2.5980762 \times 10^{-2}$$

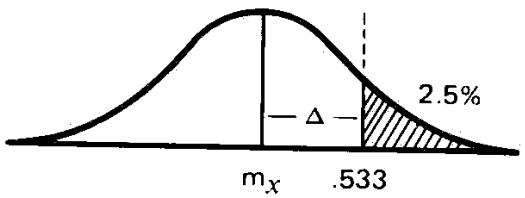
Let the confidence interval be

$$[.533 - \Delta, .533 + \Delta]$$

At best, the average yield $m_x = .533 + \Delta$ and we have



At worst, $m_x = .533 - \Delta$ and we have



Consider the case where

$$m_x = .533 - \Delta$$

We have

$$t = \frac{.533 - (.533 - \Delta)}{2.5980762 \times 10^{-2}}$$

$$= \frac{\Delta}{2.5980762 \times 10^{-2}}$$

Next, from Appendix C we have

$$t_{.975} = 2.31$$

Therefore,

$$\Delta = 2.31 \times 2.5980762 \times 10^{-2}$$
$$= 0.0600$$

Therefore,

$$.533 + \Delta = .593$$
$$.533 - \Delta = .473$$

We are 95% certain that the average yield is between .47 and .59 grams.

Hypothesis Testing

Example: Two varieties of corn are grown in adjacent plots at 10 different locations. The yields in pounds are:

Location	Variety A	Variety B
1	135	131
2	120	112
3	108	102
4	105	107
5	126	121
6	122	125
7	110	110
8	115	111
9	110	105
10	118	117

Are the variety means significantly different at the 95% level?

Solution: Let x denote variety A
y denote variety B

Then $d = x - y$ is the difference in weight of the two varieties at each location.

From test 5, Appendix A, the values

$$t = \frac{\bar{d} - m_{\bar{d}}}{s_{\bar{d}}}$$

satisfy a t distribution with 9 degrees of freedom where

$$m_{\bar{d}} = m_d = m_x - m_y$$

$$s_{\bar{d}} = \frac{s_d}{\sqrt{n}} = \frac{s_d}{\sqrt{10}}$$

We test the hypothesis

$$H_0: m_x = m_y$$

From above, we get

$$H_0: m_{\bar{d}} = 0$$

The alternate hypothesis is

$$H_1: m_x > m_y$$

This indicates a 1 tailed test.

Compute $\bar{d}$ and s_d.

135 [ENT] 131 [−] [x_n]
120 [ENT] 112 [−] [x_n]
108 [ENT] 102 [−] [x_n]
105 [ENT] 107 [−] [x_n]
126 [ENT] 121 [−] [x_n]
122 [ENT] 125 [−] [x_n]
110 [ENT] 110 [−] [x_n]
115 [ENT] 111 [−] [x_n]
110 [ENT] 105 [−] [x_n]
118 [ENT] 117 [−] [x_n]

[$\bar{x}$] ⟶ 2.8
[s] ⟶ 3.6147845

Thus

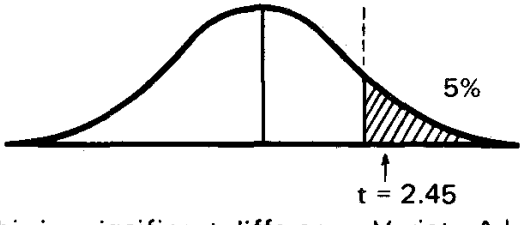
$$t = \frac{2.8 - 0.0}{\left(\frac{3.6147845}{\sqrt{10}}\right)}$$

$$= 2.4494897$$

From Appendix C, using 9 degrees of freedom,

$t_{.95} = 1.83$

We have



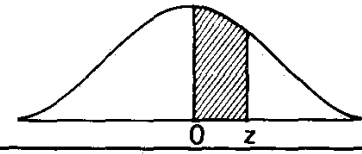
This is a significant difference. Variety A has a higher yield than Variety B.

Appendices

Appendix A. Statistical Tests

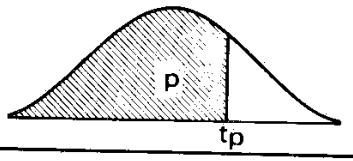
Test	Variate	Assumptions	Distribution	Transformation	Values
1	$\bar{x}$	x normal or $n \geq 30$	normal	$z = \dfrac{\bar{x} - m_{\bar{x}}}{\sigma_{\bar{x}}}$	$m_{\bar{x}} = m_x$ $\sigma_{\bar{x}} = \dfrac{\sigma_x}{\sqrt{n}}$
2	$\bar{x} - \bar{y}$	x,y normal, independent	normal	$z = \dfrac{(\bar{x} - \bar{y}) - m_{\bar{x}-\bar{y}}}{\sigma_{\bar{x}-\bar{y}}}$	$m_{\bar{x}-\bar{y}} = m_x - m_y$ $\sigma_{\bar{x}-\bar{y}} = \sqrt{\sigma_{\bar{x}}^2 + \sigma_{\bar{y}}^2}$ where $\sigma_{\bar{x}} = \dfrac{\sigma_x}{\sqrt{n_x}}\ \sigma_{\bar{y}} = \dfrac{\sigma_y}{\sqrt{n_y}}$
3	$\bar{x}$	x normal $n < 30$	t $(n - 1)$ df	$t = \dfrac{\bar{x} - m_{\bar{x}}}{s_x}$	$m_{\bar{x}} = m_x$ $s_x = \dfrac{s_x}{\sqrt{n}}$
4	$\bar{x} - \bar{y}$	x,y normal, independent	t $(n_x + n_y - 2)$ df	$t = \dfrac{(\bar{x} - \bar{y}) - m_{\bar{x}-\bar{y}}}{s_{\bar{x}-\bar{y}}}$	$m_{\bar{x}-\bar{y}} = m_x - m_y$ $s_{\bar{x}-\bar{y}} = \sqrt{s_{\bar{x}}^2 + s_{\bar{y}}^2}$ where $s_{\bar{x}} = \dfrac{s}{\sqrt{n_x}}\ \ s_{\bar{y}} = \dfrac{s}{\sqrt{n_y}}$ $s = \sqrt{\dfrac{\Sigma(x - \bar{x})^2 + \Sigma(y - \bar{y})^2}{n_x + n_y - 2}}$
5	$\bar{d} = \overline{x - y}$	x,y normal paired	t $(n - 1)$ df	$t = \dfrac{\bar{d} - m_{\bar{d}}}{s_{\bar{d}}}$	$s_{\bar{d}} = \dfrac{s_d}{\sqrt{n}} = \dfrac{s_{x-y}}{\sqrt{n}}$ $m_{\bar{d}} = m_d = m_x - m_y$

Appendix B. Areas under the Standard Normal Curve from 0 to z



z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.1	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998
3.5	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998
3.6	.4998	.4998	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.7	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.8	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.9	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000

Appendix C. Percentile Values (t_p) for Student's t Distribution with v Degrees of Freedom



v	$t_{.55}$	$t_{.60}$	$t_{.70}$	$t_{.75}$	$t_{.80}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$
1	.158	.325	.727	1.000	1.376	3.08	6.31	12.71	31.82	63.66
2	.142	.289	.617	.816	1.061	1.89	2.92	4.30	6.96	9.92
3	.137	.277	.584	.765	.978	1.64	2.35	3.18	4.54	5.84
4	.134	.271	.569	.741	.941	1.53	2.13	2.78	3.75	4.60
5	.132	.267	.559	.727	.920	1.48	2.02	2.57	3.36	4.03
6	.131	.265	.553	.718	.906	1.44	1.94	2.45	3.14	3.71
7	.130	.263	.549	.711	.896	1.42	1.90	2.36	3.00	3.50
8	.130	.262	.546	.706	.889	1.40	1.86	2.31	2.90	3.36
9	.129	.261	.543	.703	.883	1.38	1.83	2.26	2.82	3.25
10	.129	.260	.542	.700	.879	1.37	1.81	2.23	2.76	3.17
11	.129	.260	.540	.697	.876	1.36	1.80	2.20	2.72	3.11
12	.128	.259	.539	.695	.873	1.36	1.78	2.18	2.68	3.06
13	.128	.259	.538	.694	.870	1.35	1.77	2.16	2.65	3.01
14	.128	.258	.537	.692	.868	1.34	1.76	2.14	2.62	2.98
15	.128	.258	.536	.691	.866	1.34	1.75	2.13	2.60	2.95
16	.128	.258	.535	.690	.865	1.34	1.75	2.12	2.58	2.92
17	.128	.257	.534	.689	.863	1.33	1.74	2.11	2.57	2.90
18	.127	.257	.534	.688	.862	1.33	1.73	2.10	2.55	2.88
19	.127	.257	.533	.688	.861	1.33	1.73	2.09	2.54	2.86
20	.127	.257	.533	.687	.860	1.32	1.72	2.09	2.53	2.84
21	.127	.257	.532	.686	.859	1.32	1.72	2.08	2.52	2.83
22	.127	.256	.532	.686	.858	1.32	1.72	2.07	2.51	2.82
23	.127	.256	.532	.685	.858	1.32	1.71	2.07	2.50	2.81
24	.127	.256	.531	.685	.857	1.32	1.71	2.06	2.49	2.80
25	.127	.256	.531	.684	.856	1.32	1.71	2.06	2.48	2.79
26	.127	.256	.531	.684	.856	1.32	1.71	2.06	2.48	2.78
27	.127	.256	.531	.684	.855	1.31	1.70	2.05	2.47	2.77
28	.127	.256	.530	.683	.855	1.31	1.70	2.05	2.47	2.76
29	.127	.256	.530	.683	.854	1.31	1.70	2.04	2.46	2.76
30	.127	.256	.530	.683	.854	1.31	1.70	2.04	2.46	2.75
40	.126	.255	.529	.681	.851	1.30	1.68	2.02	2.42	2.70
60	.126	.254	.527	.679	.848	1.30	1.67	2.00	2.39	2.66
120	.126	.254	.526	.677	.845	1.29	1.66	1.98	2.36	2.62
∞	.126	.253	.524	.674	.842	1.28	1.645	1.96	2.33	2.58

Appendix D. Derivatives

General

$$\frac{d(c)}{dx} = 0$$

$$\frac{d(x^n)}{dx} = nx^{n-1}$$

$$\frac{d(cu)}{dx} = c\frac{du}{dx}$$

$$\frac{d(u+v)}{dx} = \frac{du}{dx} + \frac{dv}{dx}$$

$$\frac{d(u \cdot v)}{dx} = u\frac{dv}{dx} + v\frac{du}{dx}$$

$$\frac{d(u/v)}{dx} = \frac{v\left(\frac{du}{dx}\right) - u\left(\frac{dv}{dx}\right)}{v^2}$$

(Chain Rule) $\frac{dz}{dx} = \frac{dz}{dy} \times \frac{dy}{dx}$

Trigonometric

$$\frac{d(\sin x)}{dx} = \cos x$$

$$\frac{d(\sin^{-1}x)}{dx} = \frac{1}{\sqrt{1-x^2}}$$

$$\frac{d(\cos x)}{dx} = -\sin x$$

$$\frac{d(\cos^{-1}x)}{dx} = \frac{1}{\sqrt{1-x^2}}$$

$$\frac{d(\tan x)}{dx} = \sec^2 x$$

$$\frac{d(\tan^{-1}x)}{dx} = \frac{1}{1+x^2}$$

Hyperbolic

$$\frac{d(\cosh x)}{dx} = \sinh x$$

$$\frac{d(\cosh^{-1}x)}{dx} = \frac{1}{\sqrt{x^2-1}}$$

$$\frac{d(\sinh x)}{dx} = \cosh x$$

$$\frac{d(\sinh^{-1}x)}{dx} = \frac{1}{\sqrt{x^2+1}}$$

$$\frac{d(\tanh x)}{dx} = \operatorname{sech}^2 x$$

$$\frac{d(\tanh^{-1}x)}{dx} = \frac{1}{1-x^2}$$

Transcendental

$$\frac{d(\ln x)}{dx} = \frac{1}{x}$$

$$\frac{d(e^x)}{dx} = e^x$$

$$\frac{d(a^x)}{dx} = a^x \ln a$$

$$\frac{d(u^v)}{dx} = vu^{v-1} \cdot \frac{du}{dx} + \ln u \cdot u^v \cdot \frac{dv}{dx}$$

Appendix E. Integrals

$$\int du = u + C$$

$$\int a\,du = au + C \quad \text{where } a \text{ is any constant}$$

$$\int [f(u) + g(u)]\,du = \int f(u)\,du + \int g(u)\,du$$

$$\int u^n\,du = \frac{u^{n+1}}{n+1} + C \quad n \neq -1$$

$$\int \frac{du}{u} = \ln|u| + C$$

$$\int a^u\,du = \frac{a^u}{\ln a} + C$$

$$\int e^u\,du = e^u + C$$

$$\int \sin u\,du = -\cos u + C$$

$$\int \cos u\,du = \sin u + C$$

$$\int \sec^2 u\,du = \tan u + C$$

$$\int \csc^2 u\,du = -\cot u + C$$

$$\int \sec u \tan u\,du = \sec u + C$$

$$\int \csc u \cot u\,du = -\csc u + C$$

Integration by parts

$$\int u\,dv = uv - \int v\,du$$

$$\int \tan u\,du = \ln|\sec u| + C$$

$$\int \cot u\,du = \ln|\sin u| + C$$

$$\int \sec u\,du = \ln|\sec u + \tan u| + C$$

$$\int \csc u\,du = \ln|\csc u - \cot u| + C$$

$$\int \frac{du}{\sqrt{a^2 - u^2}} = \sin^{-1}\frac{u}{a} + C \quad \text{where } a > 0$$

$$\int \frac{du}{a^2 + u^2} = \frac{1}{a}\tan^{-1}\frac{u}{a} + C$$

$$\int \frac{du}{u\sqrt{u^2 - a^2}} = \frac{1}{a}\sec^{-1}\left|\frac{u}{a}\right| + C \quad \text{where } a > 0$$

$$\int \sinh u\,du = \cosh u + C$$

$$\int \cosh u\,du = \sinh u + C$$

$$\int \operatorname{sech}^2 u\,du = \tanh u + C$$

$$\int \operatorname{csch}^2 u\,du = -\coth u + C$$

$$\int \operatorname{sech} u \tanh u\,du = -\operatorname{sech} u + C$$

$$\int \operatorname{csch} u \coth u\,du = -\operatorname{csch} u + C$$

Appendix F. Mathematical Formulae

Quadratic

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial

$$(a+b)^n = \sum_{k=0}^{n} \binom{n}{k} a^{n-k} b^k$$

$$\text{where } \binom{n}{k} = \frac{n!}{k!\,(n-k)!}$$

Distance between (x_1, y_1, z_1) and (x_2, y_2, z_2)

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

Exponential and Logarithmic Identities

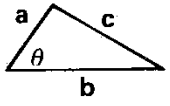
$a^\circ = 1$ $\quad (a^x)(a^y) = a^{x+y}$ $\quad \ln ab = \ln a + \ln b$

$\frac{1}{a^x} = a^{-x}$ $\quad a^x / a^y = a^{x-y}$ $\quad \ln\left(\frac{a}{b}\right) = \ln a - \ln b$

$(ab)^x = a^x b^x$ $\quad (a^x)^y = a^{xy}$ $\quad \ln(y^x) = x \ln y$

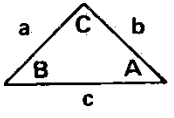
$$e = \lim_{n \to \infty} \left(1 + \frac{1}{n}\right)^n$$

Law of Cosines



$$a^2 + b^2 - 2ab\cos\theta = c^2$$

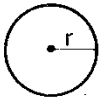
Law of Sines



$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

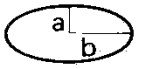
Appendix G. Geometric Formulae

Circle

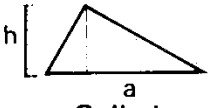


Sphere

Ellipse

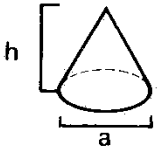


Triangle



Cylinder

Cone



Circumference

Circle	$2\pi r$

Area

Circle	πr^2
Sphere	$4\pi r^2$
Ellipse	πab
Triangle	$1/2\ ab$

Volume

Sphere	$4/3\pi r^3$
Cylinder	$\pi r^2 h$
Cone	$\frac{\pi a^2 h}{12}$

Equation

Circle	$\frac{x^2}{r^2} + \frac{y^2}{r^2} = 1$
Ellipse	$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$
Hyperbola	$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$
Parabola	$y^2 = \pm 2px$
Line	$y = mx + b$

Appendix H. Conversions

English to Metric

To Find	Multiply	By
microns	mils	**25.4**
centimeters	inches	**2.54**
meters	feet	**0.3048**
meters	yards	**0.9144**
kilometers	miles	**1.609344**
grams	ounces	28.349523
kilograms	pounds	**0.45359237**
liters	gallons(U.S.)	3.7854118
liters	gallons(Imp.)	4.546090
milliliters(cc)	fl. ounces	29.573530
sq. centimeters	sq. inches	**6.4516**
sq. meters	sq. feet	**0.09290304**
sq. meters	sq. yards	**0.83612736**
milliliters(cc)	cu. inches	**16.387064**
cu. meters	cu. feet	2.8316847×10^{-2}
cu. meters	cu. yards	0.76455486

Temperature Conversions

$$F = \frac{9}{5}(C) + 32$$

$$C = \frac{5}{9}(F - 32)$$

General

To Find	Multiply	By
atmospheres	feet of water @ 4°C	.0294990
atmospheres	inches of mercury @ 0°C	.0334211
atmospheres	pounds per sq. inch	.068046
BTU	foot-pounds	.00128593
BTU	joules	9.4845×10^{-4}
cu. ft.	cords	**128**
ergs	foot-pounds	13558200
feet	miles	**5280**
feet of water @ 4°C	atmosphere	33.8995
foot-pounds	horsepower-hours	1.98×10^{6}
foot-pounds	kilowatt-hours	2655220
foot-pounds per min.	horsepower	3.3×10^{4}
horsepower	foot-pounds per sec.	.00181818
inches of mercury @ 0°C	pounds per sq. inch	2.03602
joules	BTU	1054.3504
joules	foot-pounds	1.35582
kilowatts	BTU per min.	.01757251
kilowatts	foot-pounds per min.	2.2597×10^{-5}
kilowatts	horsepower	.7457
knots	miles per hour	0.86897624
miles	feet	1.89393×10^{-4}
nautical miles	miles	0.86897624
sq. feet	acres	**43560**
watts	BTU per min.	17.5725

Boldface numbers are exact; others are rounded.

I. Physical Constants

Name of Quantity	Symbol	Value
Speed of light in vacuum	c	2.9979×10^{8} m s^{-1}
Charge of electron	q_e	-1.602×10^{-19} C
Rest mass of electron	m_e	9.10×10^{-31} kg
Ratio of charge to mass of electron	q_e/m_e	1.759×10^{11} C kg^{-1}
Planck's constant	h	6.626×10^{-34} J s
Boltzmann's constant	k	1.381×10^{-23} J K^{-1}
Avogadro's number (chemical scale)	N_0	6.023×10^{23} molecules mole^{-1}
Universal gas constant (chemical scale)	R	8.314 J mole^{-1} K^{-1}
Mechanical equivalent of heat	J	4.185×10^{3} J kcal^{-1}
Standard atmospheric pressure	1 atm	1.013×10^{5} N m^{-2}
Volume of ideal gas at 0° C and 1 atm (chemical scale)		22.415 liters mole^{-1}
Absolute zero of temperature	0 K	−273.15° C
Acceleration due to gravity (sea level, at equator)		9.78049 m s^{-2}
Universal gravitational constant	G	6.673×10^{-11} N • m^2 kg^{-2}
Mass of earth	m_E	5.975×10^{24} kg
Mean radius of earth		6.371×10^{6} m = 3959 mi
Equatorial radius of earth		6.378×10^{6} m = 3963 mi
Mean distance from earth to sun	1 AU	1.49×10^{11} m = 9.29×10^{7} mi
Eccentricity of earth's orbit		0.0167
Mean distance from earth to moon		3.84×10^{8} m = 60 earth radii
Diameter of sun		1.39×10^{9} m = 8.64×10^{5} mi
Mass of sun	m_s	1.99×10^{30} kg = 333,000 x mass of earth
Coulomb's law constant	$k = 1/4\ \Pi\epsilon_0$	8.9874×10^{9} N • m^2 C^{-2}
Faraday's constant (1 faraday)	F	96.487 C mole^{-1}
Mass of neutral hydrogen atom	m_H^1	1.007825 amu
Mass of proton	m_p	1.007277 amu
Mass of neutron	m_n	1.008665 amu
Mass of electron	m_e	5.486×10^{-4} amu
Ratio of mass of proton to mass of electron	m_p/m_e	1836.11
Rydberg constant for nucleus of infinite mass	R_∞	109.737 cm^{-1}
Rydberg constant for hydrogen	R_H	109.678 cm^{-1}
Wien displacement law constant		0.2898 cm K^{-1}

Appendix J. Batteries and Maintenance

Your calculator uses a standard nine-volt battery type 006P available at most drug, department and camera stores. To operate, disconnect the adapter 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.

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. 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°