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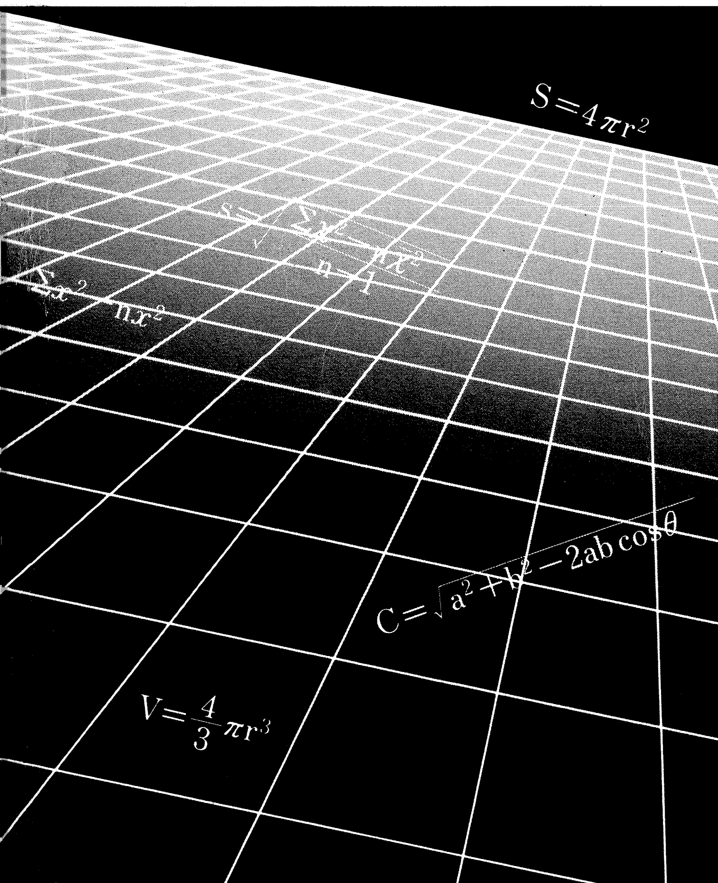
EL-506D
SCIENTIFIC CALCULATOR
OWNER'S MANUAL AND SOLUTIONS HANDBOOK



Includes Special Section on

BUSINESS and FINANCE

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The Sharp EL-506D Scientific Calculator

EL-506D = small version of EL-557

Owner's Manual and Solutions Handbook

Table Of Contents

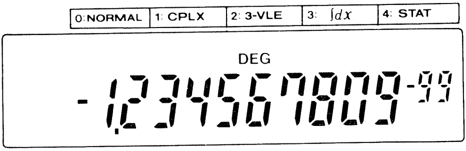
Chapter 1: *Getting Started*

This chapter introduces your Sharp scientific calculator. The calculator's keys and display screen are described, along with number entry, correcting mistakes, and the calculator's display formats and memories. The five operating modes of the calculator are also introduced.

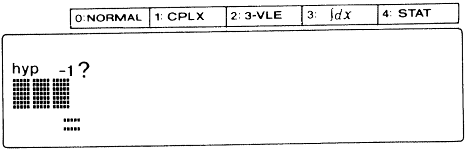
The Calculator's Display

The display of the Calculator consists of a numeric display, status indicators, and a three-character dot matrix (guidance) display.

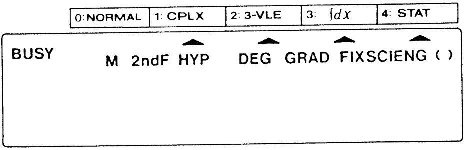
The numeric display



The dot matrix (guidance) display



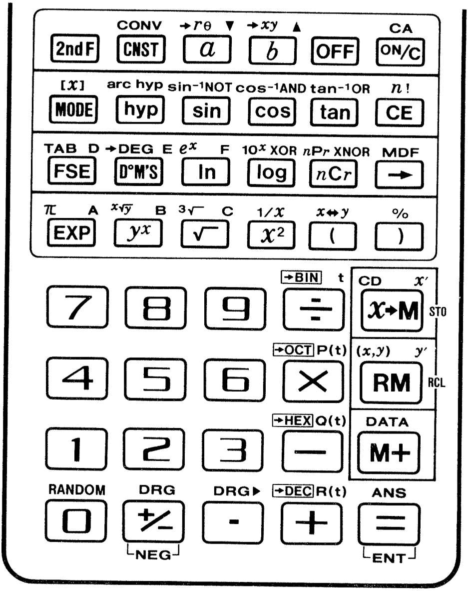
The display status indicators



You will learn the meaning of each of these displays and indicators as you read through this manual.

The Calculator's Keys

The lower rows of the calculator's keyboard contain the digit keys, simple arithmetic operation keys, and memory keys. The upper rows contain the [ON/C] and [OFF] keys, arithmetic function keys, and keys that select display formats and operating modes.



Turning the Calculator On and Off

Turn your calculator on by pressing the [ON/C] key. To turn the calculator off, press the [OFF] key. To save energy, the calculator turns itself off automatically if not used for several minutes. Pressing [ON/C] while the calculator is on clears the number in the display and any unfinished calculations.

Getting a Fresh Start

Until you are familiar with the calculator's various operating modes and display formats, it's a good idea to start by using the calculator's most basic settings. Do this as follows:

- Press the [MODE] key. The prompt **Ø ~ 4?** appears at the left end of the display.
- Press 0. This puts you in **normal** mode. Normal mode is indicated by the absence of a triangle indicator (▲) at the top of the display.
- Press [2ndF] [➡DEC] . This sets the calculator to **decimal** base (base-10) mathematics. Decimal base is indicated by the absence of a base indicator (**BIN**, **OCT**, or **HEX**) at the left end of the display.
- Press the [FSE] key repeatedly until none of the format indicators (**FIX**, **SCI**, **ENG**) appear at the top of the display. This puts the calculator in floating point format.

The absence of format and mode indicators tells you the calculator is set to normal mode, decimal base, and floating point format. However, one of the three angular unit indicators (**DEG**, **RAD**, **GRAD**) will always be present. (See Chapter 2 for details.) Unless otherwise noted, the rest of this chapter assumes that your calculator is in normal mode, using decimal base and floating point format.

Entering Numbers

Enter numbers using the digit keys [0] through [9], the decimal point key [.], and the change-sign key [+/−] . These keys are called the number entry keys.

Example: Enter the number 123.4

Press: [1] [2] [3] [.] [4]

Result: 123.4

Throughout the rest of this manual, numbers given in examples are shown normally, for example, 123.4 instead of [1] [2] [3] [.] [4].

CORRECTING ENTRIES

You can delete individual digits by using the backspace key [→] before pressing a function key. Press [→] once for each digit you want to remove. The [→] key no longer operates after a function key has been pressed.

Example:	Enter the number 42060.	
Press:	42070	A mistake.
Press:	[→] [→] 60	The remedy.
Result:	42060.	

You can also delete an entire entry by pressing the clear entry key [CE] before pressing a function key. The [CE] key no longer operates after a function key has been pressed.

Example:	Enter the number 623.61	
Press:	523.61	A mistake.

In this case it's quicker to use the [CE] key than to press [→] five times.

Press:	[CE]	The display is cleared.

USING THE SECOND FUNCTION KEY

The second function of a key is printed above it. You can use a key's second function by pressing the [2ndF] key and then the function key.

When you press [2ndF], the **2ndF** indicator appears in the upper portion of the display. This indicator tells you that you will be selecting the second function of the next key you press. If you press [2ndF] by mistake, simply press [2ndF] again to remove the **2ndF** indicator.

THE CHANGE SIGN KEY [+/–]

The [+/–] key changes the sign of the number in the display.

Example: Enter –38.

Press: 38 [+/–]

Result: –38.

Formatting the Display

The calculator can display numbers in four formats: **floating point, fixed point, scientific,** and **engineering**. Display formats are selected by pressing the [FSE] key. Pressing [FSE] repeatedly moves through the display formats in the following order: **floating point, fixed point** (**FIX**), **scientific** (**SCI**), and **engineering** (**ENG**).

FLOATING POINT DISPLAY FORMAT

The floating point format displays numbers in decimal form, using up to 10 digits. Any trailing zeros are truncated. The floating point display format is indicated by the *absence* of a format indicator (**FIX**, **ENG**, or **SCI**).

DISPLAYS WITH FIXED DECIMAL PLACES

The fixed point, scientific, and engineering formats use a fixed number of decimal places to display numbers. Select the number of decimal places displayed by using the [2ndF] [TAB] function, as follows:

- Press [2ndF] [TAB]. The prompt **Ø ~ 9?** appears at the left end of the display.
- Enter the number of decimal places desired.

FIXED POINT DISPLAY FORMAT

Select the fixed point format by pressing [FSE] until the indicator **FIX** appears in the display.

Example: Enter 3.23176 in the fixed point format, with four decimal places.

Press:	[2ndF] [TAB]	The prompt **Ø ~ 9?** appears.
	4	Display 4 decimal places.
	3.23176 [=]	
Result:	3.2318	The number is rounded to 4 decimal places.

Scientific Display Format

Select the scientific format by pressing [FSE] until the **SCI** indicator appears.

Example: Enter the number 3.1826 x 10^{-7} using the scientific format.

Press:	[2ndF] [TAB] 4	Display 4 decimal places.
	3.1826 [EXP] 6 [+/−]	Oops! Wrong exponent!
	07 [=]	07 replaces 06.
Result:	3.1826^{-07}	

Engineering Display Format

Select engineering format by pressing [FSE] until the **ENG** indicator appears.

Example: Enter the number 5.113 x 10^{8} using the engineering format.

Press:	[FSE]	Until **ENG** appears.
	[2ndF] [TAB] 3	Display 3 decimal places.
	5.113 [EXP] 8 [=]	
Result:	511.300^{06}	The exponent is changed to a multiple of three.

Memories

Each of the Sharp calculator's operating modes has a number of memories available. The memories available in normal mode are the seven **temporary memories** (M_1 through M_7), the **independent memory** (M), and the **last answer memory** (ANS). Each memory can store a single ten-digit number.

Memories available in other modes are described in the chapters discussing those modes.

THE TEMPORARY MEMORIES M_1 – M_7

Store a number from the display into a temporary memory as follows:

- Press [2ndF] [STO] . A prompt **1 ~ 7?** appears in the left portion of the display.
- Press the number key of the memory you want to store to. The **1 ~ 7?** prompt disappears, and is replaced by an indicator showing the memory you have chosen. For example, if you store to memory 3, the indicator **M3=** appears.

Recall numbers from temporary memories in a similar way:

- Press [2ndF] [RCL] . The **1 ~ 7?** prompt appears.
- Press the number key of the memory you want to recall. The **1 ~ 7?** prompt is replaced by an indicator showing which memory you have recalled.

If you press [2ndF] [STO] or [2ndF] [RCL] by mistake, you can cancel the function by pressing [2ndF] [STO] , [2ndF] [RCL] , or [ON/C] .

Example:	Store the numbers 2.04, 7984, and 10.388 in memories 1, 2, and 3, respectively.	
Press:	2.04 [2ndF] [STO]	**1 ~ 7?** appears.
	1	The indicator **M1=** appears.
	7984 [2ndF] [STO]	**1 ~ 7?** appears.

2 | **M_2=** appears.
10.388 [2ndF] [STO] | **1 ~ 7?** appears.
3 | **M_3=** appears.

Now use [2ndF] [RCL] to check the contents of the memories.

Press: [2ndF] [RCL] 1

Result: 2.04 — The contents of **M_1**.

Press: [2ndF] [RCL] 2

Result: 7984. — The contents of **M_2**.

Press: [2ndF] [RCL] 3

Result: 10.388 — The contents of **M_3**.

THE INDEPENDENT MEMORY M

Store numbers in the independent memory by pressing the **memory save** key, [x➡M], and recall them by pressing the **recall memory** key [RM]. You can also add to the number stored in the independent memory by using the **memory add** key [M+].

When a number is stored in the independent memory, the symbol **M** appears in the upper left corner of the display, and remains until the memory is cleared by storing 0 in it.

Example: Store 13 in the independent memory, verify that it has been stored, then add 14 to it.

Press: 13 [x➡M] — The indicator **M** appears at the top left of the display, and the indicator **M=** appears.

[ON/C] — The **M=** indicator disappears, but **M** remains.

[RM] — To verify storage.

Result: 13.

Press: 14 [M+] — Add 14 to the contents of the memory.

RM

Result:	27.	The sum of 13 and 14, is stored in the independent memory.

Now clear the memory by storing 0 in it.

Press:	0 x➡M	**M** disappears. **M=** appears, but disappears when any other key is pressed.

THE LAST ANSWER MEMORY

In normal mode, the calculator automatically stores the number in the display whenever = or M+ is pressed. You can recall this number, called the **last answer**, by pressing 2ndF ANS . (See the section Recalling the Last Answer in Chapter 2.)

You should keep the following points in mind when using the calculator's memories:

- When you store a number in a memory, you erase any number that was already there.
- A memory is cleared by storing the value 0 in it.
- Recalling from a memory does not affect its contents.
- The contents of the memories are retained when the calculator is turned off or shuts itself off.
- All memories except the independent memory are cleared when you change operating modes.

Operating Modes

The calculator has five powerful operating modes that greatly expand the range of calculations you can perform.

0: Normal mode. This is the mode most commonly used for everyday calculations. (See Chapter 2.)

1: Complex (CPLX) mode. This mode enables you to perform computations with complex numbers. (See Chapter 5.)

2: **Three-variable (3-VLE) mode.** This mode enables you to solve up to three simultaneous linear equations with three unknowns. (See Chapter 3.)

3: **Integration (∫dx) mode.** This mode enables you to integrate functions numerically. (See Chapter 4.)

4: **Statistics (STAT) mode.** This mode allows you to perform a wide variety of statistical calculations, including six types of regression analysis. (See Chapter 6.)

You can change operating modes as follows:

- Press [MODE] . The prompt **Ø ~ 4?** appears at the left end of the display.
- Press the number of the mode you want to enter:
  - 0 for **NORMAL** mode
  - 1 for **CPLX** mode
  - 2 for **3-VLE** mode
  - 3 for **∫dx** mode
  - 4 for **STAT** mode

Pressing [MODE] twice leaves you in the mode you started with. Except for normal mode, the mode currently in use is shown by the triangle indicator directly below the name of the mode. Normal mode is indicated by the *absence* of the indicator triangle.

The calculator retains its operating mode when it is turned off or shuts itself off.

Chapter 2:
Calculating in Normal Mode

This chapter tells you how to use your Sharp calculator in normal mode, describes the available mathematical function keys and explains how calculations are ordered, how to use the built-in physical constants and metric conversions, and how to do calculations in binary, octal, and hexadecimal numbering bases. Before proceeding, check to see that your calculator is in normal mode, with decimal base and floating point display.

Basic Arithmetic

Basic arithmetic calculations on the calculator use the arithmetic operator keys ([+] [−] [x] [÷]) and the [=] key. You enter simple calculations from left to right, just as they appear on the written page.

Example:	Calculate 5 + 3 x 4 + 2.
Press:	5 [+] 3 [x] 4 [+] 2 [=]
Result:	19.
Example:	Calculate 981.8 x 4 ÷ 5 – 6.
Press:	981.8 [x] 4 [÷] 5 [−] 6 [=]
Result:	779.44

Correcting the Wrong Operator

If you press the wrong arithmetic operation key, enter the correct operation by pressing the correct key before any other keys are pressed.

Example:	Calculate 20.25 x 15.	
Press:	20.25 [÷]	A mistake.
	[x] 15 [=]	The remedy.
Result:	303.75	

Ordering the Calculations

When you enter a calculation that consists of several operations, the calculator assigns each operation a priority as specified by the rules of algebra.

Priority	Operation
1 (first)	Functions that require only one number (sin, x^2, log, etc.)
2	Functions of two numbers (y^x, nCr, etc.)
3	x, ÷
4	+, −
5	AND
6	OR, XOR, XNOR
7 (last)	=, M+, DATA, CD

The calculator then performs the operations in order of priority. If an expression contains two or more operations having the same priority, the calculator performs these operations in the order they were entered.

Example: By the rules of algebra, 3 x 4 + 2 x 6 is calculated in the following order:

(3 x 4) + (2 x 6) = 24

The calculator calculates in this same order.

Press: 3 [x] 4 [+] 2 [x] 6 [=]

Result: 24.

PARENTHESES

You can override the calculator's default calculation priorities by using parentheses. Expressions inside parentheses are always computed first. Parentheses are entered exactly as they would appear in a written equation.

You can use up to 15 levels of parentheses in a single calculation. Open parentheses are indicated by the symbol ( ) in the upper right corner of the display. The ( ) indicator appears when the first parenthesis is opened, and remains in the display until the last parenthesis is closed on the calculation is completed by pressing [=] or [M+].

Perentheses are available only in normal and **∫dx** modes.

Example: Calculate (4 + 8) x (7 – 3) ÷ 2.

Without parentheses, the calculator would do this calculation in the order:

$$4 + (8 \times 7) - (3 \div 2) = 58.5$$

By inserting parentheses, you tell the calculator to perform the operations inside the parentheses first.

Press: [(] 4 [+] 8 [)] [x] [(] 7 [–] 3 [)] [÷] 2 [=]

Result: 24.

When the [=] or [M+] key is pressed, the calculator automatically closes any open parentheses and calculates the final result.

PENDING OPERATIONS

An operation is said to be *pending* if it is left uncompleted while the calculator performs another operation having a higher priority.

The calculator allows up to four pending operations. More than this results in an error.

Repeating Operations

The calculator enables you to repeat the last number entered or the last operation performed by pressing [=].

Repeating the Last Number

If you enter a number and press an arithmetic operator key, and then press [=] without entering a second number, the calculator will use the number in the display as the second number for the calculation.

Example:	Calculate 64 x 64.	
Press:	64 [x] [=]	The calculator repeats 64.
Result:	4096.	

Repeating the Last Arithmetic Operation

When you use the multiplication operator [x], the calculator remembers the *first* number entered.

Example:	Multiply 7 and 0.5 by 16.	
Press:	16 [x] 7 [=]	
Result:	112.	
Press:	.5 [=]	The calculator remembers 16 [x].
Result:	8.	

When you use the arithmetic operators [+], [−], or [÷], the calculator remembers the operator and *second* number used in the previous calculation.

Example:	Divide 180 by 10 repeatedly.
Press:	180 [÷] 10 [=]
Result:	18.

Press:	[=]	The calculator remembers [÷] 10.
Result:	1.8	

Example: Subtract 13 from 27 and –64.

Press:	27 [–] 13 [=]	
Result:	14.	
Press:	64 [+/–] [=]	The calculator remembers [–] 13
Result:	–77.	

THE EXCHANGE KEY

or ↕ on EL-557

Pressing the exchange key [2ndF] [x↔y] exchanges the number being used in repeated arithmetic operations with the number in the display. Pressing [2ndF] [x↔y] again switches the numbers back.

Example: Divide 10 by 2.

Press:	10 [÷] 2 [=]	
Result:	5.	

Now exchange 2 with 5.

Press:	[2ndF] [x↔y]	
Result:	2.	5 is now the constant divisor.
Press:	10 [=]	
Result:	2.	

Whenever you press [2ndF] [x↔y] and then a new arithmetic operator key, the calculator performs that operation using the last result or the last number entered.

Example: Continue from the previous example.

Press:	[2ndF] [x↔y] [–] [=]	Subtract 2 from 2.
Result:	0.	

RECALLING THE LAST ANSWER

Whenever you press [=] or [M+], the calculator automatically stores the result in its last answer memory. You can recall this last answer by pressing [2ndF] [ANS] .

Example:	Divide 25 by 4, then divide 100 by the result.	
Press:	25 [÷] 4 [=]	
Result:	6.25	This number is stored in the last answer memory.
	100 [÷] [2ndF] [ANS]	
Result:	**ANS=** 6.25	The last answer is recalled to the display.
	[=]	
Result:	16.	

THE MODIFY KEY

The calculator stores calculated results in an unformatted form with up to twelve digits, plus two additional digits for an exponent (if any). The calculator uses this number in further calculations, eliminating common round-off errors.

Pressing the [2ndF] [MDF] key replaces the calculator's unformatted internal version of a number with the number in the display.

Example:	At a fixed accuracy of 2 decimal places, compare the calculations of 1 ÷ 3 = 0.33 and 1 ÷ 3 x 3 = 1.00.	
Press:	[FSE]	Until **FIX** appears.
	[2ndF] [TAB] 2	Display 2 decimal places.
Press:	1 [÷] 3 [x]	The display shows 0.33, but uses 0.33333333333 in later calculations.

3 [=]

Result: 1.00 — Not 0.99.

Re-calculate 1 ÷ 3 x 3, and use the modify key to replace the calculated value of 1/3 with 0.33.

Press: 1 [÷] 3 [=]

[2ndF] [MDF] [x] 3 [=] — The calculator now uses 0.33 in any later calculations.

Result: 0.99

Now change to floating point format.

Press: [FSE] — Until no display format indicator appears.

Result: 0.99

Function Keys

The calculator's function keys enable you to perform a wide variety of mathematical operations.

Reciprocals

Calculate the reciprocal of the number in the display by pressing [2ndF] [1/x].

Example: Calculate the reciprocal of 974.87.

Press: 974.87 [2ndF] [1/x]

Result: 0.001025777

Percentages

Pressing the [2ndF] [%] key converts the number in the display into a percentage. This number can then be used in calculations.

The [2ndF] [%] key also simplifies arithmetic involving percentages as shown in examples below.

Example: Increase 38 by 15%.

Press: 38 [+] 15 [2ndF] [%] [=]

Result: 43.7

Example: Calculate 47% of 219.

Press: 219 [x] 47 [2ndF] [%] [=]

Result: 102.93

POWER FUNCTIONS

The [x^2] key calculates the square of the number in the display.

Example: Calculate the square of 15.

Press: 15 [x^2]

Result: 225.

The [y^x] key raises a number y to the power x. Use it as follows:

Example: Calculate 7 to the 4th power.

Press: 7 [y^x] 4 [=]

Result: 2401.

The [$\sqrt{\ }$] key calculates the square root of the number in the display.

Example: Calculate the square root of 27.

Press: 27 [$\sqrt{\ }$]

Result: 5.196152423

The [2ndF] [$\sqrt[3]{\ }$] key calculates the cube root of the number x.

Example: Find the cube root of 1234.

Press: 1234 [2ndF] [$\sqrt[3]{\ }$]

Result: 10.72601467

The [2ndF] [$\sqrt[x]{y}$] key calculates the xth root of the number y.

Example: Find the 5th root of 243.

Press: 243 [2ndF] [$\sqrt[x]{y}$] 5 [=]

Result: 3.

The [2ndF] [$n!$] key calculates the factorial of the number in the display.

Example: Calculate 14!.

Press: 14 [2ndF] [$n!$]

Result: 8.71782912^{10}

LOGARITHMIC/EXPONENTIAL FUNCTIONS

The common logarithm key [log] displays the base 10 logarithm of the number in the display.

Example: Calculate the common logarithm of 31.62.

Press: 31.62 [log]

Result: 1.499961866

The natural logarithm key [ln] displays the base *e* logarithm of the number in the display.

Example: Calculate the natural logarithm of 31.62.

Press: 31.62 [ln]

Result: 3.453789832

The [2ndF] [10^x] key raises 10 to the power of the number in the display.

Example: Calculate $10^{4.7}$.

Press: 4.7 [2ndF] [10^x]

Result: 50118.72336

The [2ndF] [e^x] key raises *e* to the power of the number in the display.

Example: Calculate e^1.

Press: 1 [2ndF] [e^x]

Result:	2.718281828	This is the base number *e*.

TRIGONOMETRIC FUNCTIONS

Your Sharp calculator enables you to perform trigonometric calculations using any of three units of angular measure: degrees, radians, and grads. Select the angular units you want to use by pressing the [2ndF] [DRG] key. The unit selected is shown by an indicator (**DEG**, **RAD**, or **GRAD**) at the top of the display.

SINES, COSINES, AND TANGENTS

The [sin], [cos], and [tan] keys calculate the sine, cosine, and tangent of the value in the display.

Example:	Calculate sin 30° and cos 0.8775 radians.	
Press:	[2ndF] [DRG]	Until **DEG** appears.
	30 [sin]	
Result:	0.5	
Press:	[2ndF] [DRG]	Until **RAD** appears.
	.8775 [cos]	
Result:	0.639075998	

The [2ndF] [$\sin^{-1}$], [2ndF] [$\cos^{-1}$], and [2ndF] [$\tan^{-1}$] keys calculate the arcsine ($\sin^{-1}$), arccosine ($\cos^{-1}$), and arctangent ($\tan^{-1}$) of the number in the display.

Example:	Calculate $\sin^{-1}$ 0.76 in degrees.	
Press:	[2ndF] [DRG]	Until **DEG** appears.
	.76 [2ndF] [$\sin^{-1}$]	
Result:	49.46419789	

THE PI KEY

Pressing [2ndF] [π] enters the value of pi. Only the first 10 digits are displayed, but the calculator uses 12 digits in calculations.

Example: Recall pi.

Press: [2ndF] [π]

Result: 3.141592654

CONVERTING AMONG ANGULAR UNITS

The calculator allows you to easily convert angles from one angular unit to another. Do this as follows:

- Press [2ndF] [DRG] repeatedly until the angular unit you are converting *from* is indicated in the display.
- Enter the angle you want to convert.
- Press [2ndF] [DRG ▶] repeatedly until the calculator indicates the angular units you are converting *to*. (Note that the [DRG] key is not the same as the [2ndF] [DRG ▶] key). The calculator automatically converts the angle to the new units.

Example: Convert 90 degrees into radians and grads.

Press: [2ndF] [DRG] Until **DEG** appears.

90

Convert this into radians:

Press: [2ndF] [DRG ▶] **RAD** appears.

Result: 1.570796327

Now convert to grads:

Press: [2ndF] [DRG ▶] **GRAD** appears.

Result: 100.

A MATTER OF DEGREE

The calculator can also perform calculations on numbers in *sexagesimal* (base 60) form. Sexagesimal calculations are available in statistics and normal modes.

Sexagesimal form represents angles and time using the form DD°MM'SS.SS, where DD represents the number of degrees or hours, MM represents the number of minutes, and SS.SS represents the number of seconds. Enter angles in sexagesimal form using the [D°M'S] key.

If you make a mistake while entering a number, just type in the correct number. The last digits entered will replace the previous ones.

Example: Enter 24 degrees, 34 minutes, 30.27 seconds.

Press: 24 [D°M'S]

34 [D°M'S]

30 [D°M'S]

27

Result: 24°34'30.27

CHANGING FORMS

You can easily convert numbers from sexagesimal to decimal form, or vice versa, using the [D°M'S] and [2ndF] [→DEG] keys.

Convert angles from sexagesimal to decimal form by pressing [2ndF] [→DEG].

Example: Convert 12°39'18" to decimal form.

Press: 12 [D°M'S] 39 [D°M'S] 18

[2ndF] [→DEG]

Result: 12.655

Convert angles from decimal to sexagesimal form using the [D°M'S] key. The number in the display must contain a decimal point.

Example: Convert 123.432° into sexagesimal form.

Press: 123.432 [D°M'S]

Result: 123°25'55.20

TIME

The calculator's sexagesimal form can also be used to express time in hours, minutes, and seconds.

Example: Add 8 hours, 21 minutes, 42 seconds; 15 hours, 3 minutes, 39.5 seconds; and 1 hour, 45 minutes

Press: 8 [D°M'S] 21 [D°M'S] 42 [+]
15 [D°M'S] 3 [D°M'S] 39 [D°M'S] 50 [+]
1 [D°M'S] 45 [=]

Result: 25°10'21.50 — 25 hours, 10 minutes, and 21.5 seconds.

CALCULATIONS IN SEXAGESIMAL AND DECIMAL

The calculator allows you to add, subtract, multiply and divide sexagesimal and decimal numbers at the same time. The following table shows the resulting forms of arithmetic operations involving both decimal and sexagesimal numbers.

Addition/ Subtraction	sexagesimal (+, –) sexagesimal = sexagesimal sexagesimal (+, –) decimal = decimal decimal (+, –) sexagesimal = decimal
Multiplication/ Division	sexagesimal (x, ÷) sexagesimal = decimal sexagesimal (x, ÷) decimal = sexagesimal decimal x sexagesimal = sexagesimal decimal ÷ sexagesimal = decimal

Example: Add 5°45'30 to 16.5 and to 31°19.

Press: 16.5 [+] 5 [D°M'S] 45 [D°M'S] 30 [=]

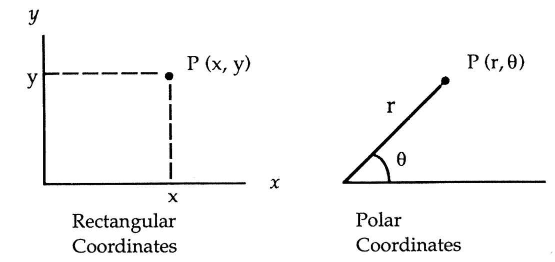
Result: 22.25833333

Press: 31 [D°M'S] 19 [=]

Result: 37°04'30.00

POLAR AND RECTANGULAR COORDINATES

The calculator enables you to convert between rectangular and polar coordinates quickly and easily. When using these conversions, make sure the calculator is set for the angular units (**DEG**, **RAD**, or **GRAD**) you are using.



Converting from Rectangular to Polar

Convert from rectangular coordinates to polar coordinates as follows:

- Enter the x coordinate and press [*a*] . The indicator **a=** appears at the left end of the display.
- Enter the y coordinate and press [*b*] . The indicator **b=** appears.
- Press [2ndF] [→*r*θ] . The radius r is displayed immediately, with the indicator **a=**. Press [*b*] to display the angle θ, with the indicator **b=**. Press [*a*] to display the radius again.

Example: Convert (3, 4) into polar coordinates.

Press:	[2ndF] [DRG]	Until **DEG** appears.
	3 [*a*] 4 [*b*] [2ndF] [→*r*θ]	
Result:	**a=** 5.	This is the radius.
Press:	[*b*]	
Result:	**b=** 53.13010235	This is the angle θ in decimal degrees.

Converting from Polar to Rectangular

Convert from polar coordinates to rectangular coordinates as follows:

- Enter the radius r and press [*a*] . **a=** appears.
- Enter the angle θ and press [*b*] . **b=** appears.

- Press [2ndF] [→xy]. The x coordinate is displayed immediately, along with the indicator **a=**. Press the [*b*] key to display the y coordinate (**b=** also appears). Press [*a*] to display the x coordinate again.

Example: Convert r = 1, θ = 30° into rectangular coordinates.

Press: [2ndF] [DRG] Until **DEG** appears.

1 [*a*] 30 [*b*] [2ndF] [→xy]

Result: **a=** 0.866025403 This is the x coordinate.

Press: [*b*]

Result: **b=** 0.5 This is the y coordinate.

HYPERBOLIC FUNCTIONS AND THEIR INVERSES

Example: Calculate the sinh of π

Press: [2ndF] [π] [hyp] [sin]

Result: 11.54873936

Example: Calculate the $\cosh^{-1}$ of 5.

Press: 5 [2ndF] [arc hyp] [cos]

Result: 2.29243167

COMBINATIONS AND PERMUTATIONS

COMBINATIONS

The combinations key [*nCr*] calculates the number of possible combinations of r items that can be selected out of a set containing *n* items.

Example: How many combinations of 3 items can you select out of a set of 15 items?

Press: 15 [nCr] 3 [=]

Result: 455.

PERMUTATIONS

The permutations key [2ndF] [nPr] calculates the number of *possible orderings* of *r* items taken from a set of *n* items.

Example: How many permutations of 3 items can you select out of a set of 15 items?

Press: 15 [2ndF] [nPr] 3 [=]

Result: 2730.

RANDOM NUMBERS

Pressing the [2ndF] [RANDOM] key displays a three decimal place random number between 0.000 and 0.999.

Example: Generate a random number.

Press: [2ndF] [RANDOM]

Result: 0.659 — The number you generate will of course be different.

You can use random numbers in expressions just as any other number.

Using the Physical Constants

Your calculator contains the values of 30 commonly used physical constants (see Appendix A) which are available only in decimal base normal mode.

You call up the physical constants with the constant key [CNST], in one of three ways.

- Enter the number of the constant (from the table in Appendix A) and press [CNST].
- Alternately, press [CNST]. This calls up the last constant used. You can then scroll up and down the list using the

[▲] and [▼] keys. You can scroll continuously by holding down either of these keys.

- You can also scroll through the list by holding down the [CNST] key.

Example: Call up g, the acceleration of gravity (number 3 in the table in Appendix A).

Press: 3 [CNST]

Result: **g=** 9.80665

The physical constants are inserted into a calculation just as any other number.

Example: Multiply the mass of an electron by 60. (The electron mass is number 4 in the table.)

Press: 60 [x] 4 [CNST] [=]

Result: 5.46563382^{-29}

Using the Metric Conversions

The calculator has a built-in metric conversion feature (See Appendix A) that is available only in decimal base normal mode. Perform conversions as follows:

- Enter the number you want to convert.
- Press [2ndF] [CONV] .
- Use the [▲] and [▼] keys to scroll through the list of units until the unit you are converting *from* appears.
- Press [→] to perform the conversion. Pressing [→] again converts the number back to its original unit.

Example: Convert 535 miles into kilometers.

Press: 535 [2ndF] [CONV]

[▲] or [▼] Until **mi**→? appears.

[→]

Result: →**km** 860.99904 In kilometers.

As with physical constants, metric conversions can be performed while entering an expression.

Example: Convert 42.7 pounds into kilograms, add 71.6, and multiply by 3.

Press: 3 [x] [(] 42.7 [2ndF] [CONV]

[▲] or [▼] Until **lb**→? appears.

[→] [+] 71.6 [=]

Result: 272.9051826

Calculating With Other Bases

The calculator can add, subtract, multiply, and divide binary (base 2), octal (base 8), and hexadecimal (base 16) numbers. Other mathematical functions are not a available.

Select the number base you want to use with the [2ndF] [→BIN], [2ndF] [→OCT], [2ndF] [→HEX], or [2ndF] [→DEC] keys. The **BIN**, **OCT**, and **HEX** indicators show you which base you are using. (If none of the indicators appear in the display, you are in decimal base.)

Binary, Octal, and Hexadecimal Base Calculations

Example: Add the binary numbers 1 and 1.

Press: [2ndF] [→BIN] **BIN** appears.

1 [+] 1 [=]

Result: 10.

Example: Multiply the octal numbers 5 and 5.

Press: [2ndF] [→OCT] **OCT** appears.

5 [x] 5 [=]

Result: 31.

Example: Multiply the hexadecimal numbers A1 and 4F.

Press: [2ndF] [→HEX] **HEX** appears.

A1 [x] 4F [=]

Result: 31AF.

Take care when reading the display to distinguish between the digit 6 and the letter b. They appear similar in the display.

NEGATIVES AND COMPLEMENTS

In binary, octal, and hexadecimal bases, pressing the [NEG] key gives the complement of the number in the display.

Example: Calculate the ten-bit complement of the binary number 10110.

Press: [2ndF] [→BIN]

10110 [NEG]

Result: 1111101010.

CONVERTING BETWEEN BASES

When you switch to a new base, the calculator attempts to convert the number in the display into the new base. If the number cannot be represented in the new base in 10 digits, the calculator still changes base, but it displays an "-E-" error message. Clear the error by pressing [ON/C].

If you convert a number containing a fraction from decimal to another base, the fraction will be truncated.

Example: Convert the decimal number 123 into binary, octal, and hexadecimal base.

Press: [2ndF] [→DEC] 123 The decimal number.

[2ndF] [→BIN]

Result: 1111011. Binary form.

Press: [2ndF] [→OCT]

Result: 173. Octal form.

Press: [2ndF] [→HEX]

Result: 7b. Hexadecimal form.

Keep the following rule in mind when converting from binary, octal, or hexadecimal base to decimal: If the alternate base number displayed is greater than half the maximum value that can be represented in the 10 display digits, the calculator considers the decimal equivalent to be negative.

USING THE BOOLEAN FUNCTIONS

The calculator enables you to perform calculations using the boolean functions NOT, AND,OR, XOR, and XNOR. These functions are available in binary, octal, and hexadecimal bases.

When in binary, octal, or hexadecimal, the boolean function becomes the only function of its key. The normal function of the key is inactive.

Example: Calculate 57 AND E6 in hexadecimal.

Press: [2ndF] [→HEX]

57 [AND] E6 [=]

Result: 46.

The boolean functions operate on the number in the display as if it had 10 digits. If the number actually has less than 10 digits, the calculator internally pads the number with leading zeros, though these leading zeros are not displayed. This internal 10 digit number is then used in later calculations.

Example: Calculate NOT (FFF) in hexadecimal. This actually calculates NOT (0000000FFF).

Press: [2ndF] [→HEX]

FFF [NOT]

Result: FFFFFFF000.

Chapter 3: *Three-Variable Linear Equations*

This chapter describes using your calculator's 3-VLE mode to solve three-variable linear equations.

THE THREE EQUATIONS

3-VLE mode solves simultaneous equations of the form:

$$a_1x + b_1y + c_1z = d_1$$
$$a_2x + b_2y + c_2z = d_2$$
$$a_3x + b_3y + c_3z = d_3$$

where x, y, and z are unknown.
These equations can also be written in matrix form:

$$\begin{pmatrix} a_1b_1c_1 \\ a_2b_2c_2 \\ a_3b_3c_3 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} d_1 \\ d_2 \\ d_3 \end{pmatrix}$$

In 3-VLE mode, you just key in the known values in the correct order, and the calculator automatically solves for x, y, and z. The calculator also finds the determinant of the matrix.
If the determinant of the matrix equals zero, then x, y, and z cannot be solved, and the calculator displays an error "-E-".
Press the [ON/C] key to clear the error.

SOLVING 3-D LINEAR EQUATIONS

Set the calculator to 3-VLE mode by pressing [MODE] 2.

THE 3-VLE KEYS

The temporary, independent, and last answer memories are inactive in 3-VLE mode. In addition, the following keys are not available:

- [*a*], [*b*], [2ndF] [→rθ] and [2ndF] [→*xy*]

- D°M'S and 2ndF →DEG
- (,) , and 2ndF %
- 2ndF RANDOM
- x→M , RM , and M+

The = key assumes the function of the ENT key, and is used to enter the known values of your equations.

Entering The Known Values

In 3-VLE mode, the calculator prompts you for each of the 12 known values from your system of simultaneous equations. You enter values using the ENT key, as follows:

- When you enter 3-VLE mode, the calculator displays the prompt **a1?**. Enter the value of **a1**, and press ENT.
- The prompt **b1?** appears. Enter the value of **b1**, and press ENT.
- The prompt **c1?** appears. Enter the value of **c1**, and press ENT.
- The prompt **d1?** appears. Entr the value of **d1**, and press ENT.

This procedure is repeated until all 12 known values have been entered.
You must enter zeros for any missing terms in your equations. For example, if your first equation is 3x+ 5z=17, you would use **a1=** 3, **b1=** 0, **c1= 5**, and **d1=** 17.

Displaying The Solution Vector

When you press ENT after entering the value of d3, the calculator calculates and displays the value of x. Display the values of y, z, and the determinant by pressing ENT. An indicator (**x=**, **y=**, **z=**, or **det=**) appears with each of the displayed values to identify it.
While the calculator is calculating these values, the display is cleared briefly, and a **BUSY** indicator appears in the left of the display.

A Quick Example of a 3-VLE Solution

Try the following example.

Example: Solve $\begin{pmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 1 \\ -1 \\ 1 \end{pmatrix}$

Press: [MODE] 2 — Select 3-VLE mode.

1 [ENT] 1 [ENT] 0 [ENT] 1 [ENT]

0 [ENT] 1 [ENT] 1 [ENT] 1 [+/−] [ENT]

1 [ENT] 0 [ENT] 1 [ENT] 1 [ENT]

Result: **x=** 1.5

Press: [ENT]

Result: **y=** –0.5

Press: [ENT]

Result: **z=** –0.5

Press: [ENT]

Result: **det=** 2.

Viewing or Changing the Values You Entered

After solving a 3-VLE problem, if you immediately press [ENT], the calculator prompts for entry of the constants again, starting with **a1**. The display shows the previous value entered for each of the constants.

You can accept the previously entered values by pressing [ENT], or you can enter new values. The calculator then solves the 3-VLE equation as before. In this way, you can view and verify the values you enter. Or, if you have a similar problem to solve that requires changing just a few of the constants, you can change only those constants.

If you press [MODE] 2 or [2ndF] [CA], all entered values are cleared and the calculator prompts for entry of a_1.

It the values of c_1, c_2 and a_3, b_3, c_3, d_3 are entered as 0. simultaneous linear equations with two unknowns can also be solved.

Chapter 4:
Integrations

This chapter describes how to integrate functions using Sharp calculator in integration (∫**dx**) mode. Your calculator performs numerical integrations using Simpson's Rule.

The Details of Integration on the Calculator

The steps you use to integrate with the calculator are as follows:

- Select ∫**dx** mode by pressing [MODE] 3.
- Enter the function you want to integrate.
- Enter the lower and upper limits of integration (**a** and **b**, respectively).
- Enter the number of subdivisions, **n**.

The result is a numerical approximation of the exact solution. The accuracy of the approximation depends on the function you're integrating, and the number of subdivisions you use.

ENTERING F(X)

Enter the function f(x) much the same as you would an expression for a calculation. Use the [2ndF] [[x]] key to enter the variable x into the function. Your function can have up to 23 steps, and can contain any of the following:

- The [x] function, any digits, and exponents.
- The logarithmic, power, root, and inverse (1/x) functions.
- The trigonometric functions and their inverses. (If f(x) involves trigonometric functions, be sure the calculator is set for the same trigonometric units used in the integration limits.)
- The hyperbolic functions and their inverses.

• Parentheses.

You must use [2ndF] [[x]] to enter x into an expression. If, for example, you want to integrate x^2 over an interval, you must enter [2ndF] [[x]] and then [x^2] : entering [x^2] alone gives a result of zero.

When you've entered all the steps of f(x), press [ENT] . This tells the calculator that f(x) is complete.

WHAT'S SHOWING IN THE DISPLAY?

While you're entering f(x), the steps are displayed in small characters at the left end of the display, and the **step number** is displayed in square brackets. The **step number** tells you which step is displayed and the total number of steps in f(x). For example, if you're displaying step 4 of 10, the step number is displayed as **[04–10]**.

At any time while you're entering f(x), you can use the [▲] and [▼] keys to review the steps you've entered.

If you attempt to enter more than 23 teps, the error indicator "-E-" appears in the display. Clear the error by pressing the [ON/C] key.

LIMITS AND SUBDIVISIONS

After you've entered f(x), you're ready to enter the lower and upper limits of integration, and the number of subdivisions you want to use. Do this as follows:

- After you've keyed in f(x) and pressed [ENT], the prompt **a?** appears. Enter the lower integration limit **a**, and press [ENT].
- Once you've entered **a**, the prompt **b?** appears. Enter the upper integration limit **b**, and press [ENT].

Some integration problems have 0 as one of the integration limits, but f(x) is undefined at x = 0. In this case, if you enter 0 for **a** or **b**, an error results. One way around this is to enter a value for the limit that is as close to zero as possible without being equal to zero. On the calculator, this number is 1×10^{-99} (or -1×10^{-99} if the other limit is negative).

- The prompt **n?** appears. Enter the number of subdivisions **n**, and press [ENT]. **n** can be any integer between 1 and 4999999999.

In general, the larger **n** is, the more accurate the results of your integration will be. However, large values of **n** also increase the time required to compute the result.

Now that you know how to enter an integration calculation, try the following example.

Example: Using 10 subdivisions, solve the definite integral:

$$\int_2^8 (x^3 - 0.5x^2 + 6)\,dx.$$

In this example, the right hand, column shows what the calculator displays after each entry.

Press: [MODE] 3 — Select ∫**dx** mode. The **fx?** indicator is displayed.

Press:		
[2ndF] [[x]]	***x***	**[01-01]**
[y^x]	**y*x***	**[02-02]**
3	**3**	**[03-03]**
[−]	**–**	**[04-04]**
.	**.**	**[05-05]**
5	**5**	**[06-06]**
[×]	**x**	**[07-07]**
[2ndF] [[x]]	***x***	**[08-08]**
[x^2]	***x*²**	**[09-09]**
[+]	**+**	**[10-10]**
6	6	**[11-11]**
[ENT]	**a?**	**0.**
2 [ENT]	**b?**	**0.**

	8 [ENT]	$n^?$	0.
	10 [ENT]		

The result takes a few seconds to calculate. The calculator displays the word **BUSY** while it is calculating.

Result: $\int$ **dx**= 972.

If you wish to interrupt integration during computation, press the [ON/C] key. The display will return to "fx?".

CORRECTING WRONG ENTRIES

If you press the wrong key while entering a function, simply press [CE] immediately to erase the error. You can then enter the correct key.
If you want to erase everything you've entered so far, press [2ndF] [CA]. The prompt **fx?** appears, and you can begin entering f(x) again.

Example: Evaluate the integral:

$$\int_3^8 (15x^3)\, dx.$$

Use 10 subdivisions.

Press:	[MODE] 3	Select the integration mode.	
Result:	**fx?**	The calculator is ready to accept your function.	
Press:	15	**5**	**[02-02]**
	[x]	**x**	**[03-03]**
	[2ndF] [[x]]	***x***	**[04-04]**
	[y^x]	**y*x***	**[05-05]**
	6	**6**	**[06-06]**

Oops! That exponent should have been a 3, not a 6.

	[CE]	**y*x***	**[05-05]**

	3	**3**	**[06-06]**
	ENT	**a?**	0.
	3 ENT	**b?**	0.
	8 ENT	**n?**	0.
	10 ENT		
Result:	**∫dx=** 15056.25		

CHANGING F(X)

You can change the steps in your function f(x) while you're entering it, or after you've finished an integration.

DELETING STEPS

While you're entering f(x), you can delete steps by using the ▲ and ▼ keys to display the step you want to delete, and pressing CE.

If you want to delete a step after you've finished an integration, you must first press ENT to gain access to f(x).

When you're happy with f(x), press ENT. (You don't have to move to the last step of f(x) before pressing ENT.)

Example: Change the function you entered in the last example from $15x^3$ to x^3, and reevaluate the integral.

Press:	ENT	To gain access to f(x). **fx?** appears.
	▲ or ▼	Until **1 [01-06]** appears in the display.
	CE	**fx?** reappears.
	▲ or ▼	Until **5 [01-05]** appears in the display.
	CE	**fx?** reappears.
	▲ or ▼	Until **x [01-04]** appears in the display.
	CE	**fx?** reappears.

You can now use the [▲] and [▼] keys to check that f(x) is x^3. Notice that when you scroll to the end of f(x), **fx?** reappears.

Press:	[ENT]	**a?**	3.
	[ENT]	**b?**	8.
	[ENT]	**n?**	10.
	[ENT]		

Result: **∫dx=** 1003.75

INSERTING STEPS

When you insert a step, it is placed into the function f(x) in the position immediately after the step in the display. To insert a step into f(x), use the [▲] and [▼] keys to display the step after which you want to insert more steps, then enter the new steps. The new steps are inserted into f(x) without affecting the other steps. When you're happy with f(x), press [ENT].

Example: Change the function from the last example from x^3 to x^{23}, and evaluate the integral.

Press:	[ENT]		
	[▲] or [▼]	Until **yx [02-03]**, appears in the display.	
	2	**2**	**[03-04]**

Use the [▲] and [▼] keys to check that f(x) is now x^{23}.

Press: [ENT] [ENT] [ENT] [ENT]

Result: **∫dx=** 1.970197472^{20}

SAME F(X), DIFFERENT LIMITS

After you perform an integration, you can integrate the same f(x) again, with different limits of integration and a different number of subdivisions. Do this as follows:

- Press [ENT] twice. **a?** appears, along with the current value of **a**. Change **a** by entering its new value, and press [ENT]. If you want to leave **a** unchanged, just press

[ENT] .

- After you press [ENT], **b?** appears, along with the current value of **b**. Change **b** by entering its new value, and press [ENT]. If you want to leave **b** unchanged, just press [ENT].
- After you press [ENT], **n?** appears, along with the current value of **n**. Change **n** by entering its new value, and press [ENT]. If you want to leave **n** unchanged, just press [ENT].

Example: Using 4 subdivisions, solve the definite integral:

$$\int_0^1 e^{-x2}\,dx.$$

Press: [2ndF] [[x]] [x^2] [+/–] [2ndF] [e^x] [ENT]

0 [ENT]	The lower limit, **a**.
1 [ENT]	The upper limit, **b**.
4 [ENT]	The subdivisions, **n**.

Result: **∫dx=** 0.74682612

Example: Solve the same integral, but change the lower limit from 0 to –1:

Press:

[ENT] [ENT]	Don't change **fx**.
1 [+/–] [ENT]	Change **a** to **–1**.
[ENT]	Use the same **b**.
[ENT]	Use the same **n**.

Result: **∫dx=** 1.49371076

Example: Solve the same integral again, this time using 10 subdivisions.

Press:

[ENT] [ENT]	Don't change **fx**.
[ENT]	Use the same **a**.
[ENT]	Use the same **b**.

10 ENT Set **n** = 10.

Result: ∫ **dx=** 1.493649897

Simpson's Rule

The approximation S is given by:

$$S = \frac{h}{3}\{f(a) + 4\{f(a+h) + f(a+3h) + \cdots + f(a+(N-1)h)\} + 2\{f(a+2h) + f(a+4h) + \cdots + f(a+(N-2)h)\} + f(b)\}$$

where $h = \frac{b-a}{N}$, $N = 2n$, integration interval [a, b]

In general, the more subdivisions you use, the more accurate your results will be. However, using more subdivisions also increases the time needed to compute a result.

It is also important to notice that the relationship between **n** and the accuracy of the result depends on the shape of f(x). Generally, the closer f(x) can be approximated by a parabola over each of the **n** subdivisions, the more accurate your results will be.

Chapter 5:
Calculations Using Complex Numbers

This chapter tells you how to use your Sharp calculator for arithmetic with complex numbers.

Select the complex numbers mode by pressing [MODE] 1. When you are in complex mode, the indicator triangle points to **1: CPLX** above the display. Exit from complex mode by pressing [MODE] again to select a different mode.

Calculating in Complex Mode

The calculator enables you to add, subtract, multiply, and divide complex numbers. It also lets you change between two coordinate systems used to represent complex numbers. You can perform mathematical functions on either the real or imaginary parts of complex numbers, but not on both parts of the number at once.

The independent, temporary, and last answer memories are inactive in complex mode. Constant calculations are also not available. In addition, the following keys are inactive:

- [nCr] and [2ndF] [nPr]
- [D°M'S] and [2ndF] [→DEG]
- [(], [)], [2ndF] [$x \leftrightarrow y$], and [2ndF] [%]
- [y^x] and [2ndF] [$\sqrt[x]{y}$]

Entering Complex Numbers

To perform arithmetic with complex numbers, you need to enter both the real and imaginary parts of a complex number. If either part of the number is zero, you need only enter the other part.

Enter complex numbers as follows:

- Enter the real part of the number and press [a] .
- Enter the imaginary part of the number and press [b] .

Example: Enter the complex number 11 + 7i.

Press:	[MODE] 1	Select complex mode.
	11 [a]	
Result:	**a=** 11.	
	7 [b]	
Result:	**bi=** 7.	

CORRECTING WRONG ENTRIES

If you make a mistake while entering one part of a number, you may enter that part again before performing an arithmetic operation. Be sure to press [a] or [b] to identify which part is being corrected.

Example: Enter 6 + 4i.

Press:	5 [a]	A mistake.
	4 [b]	
	6 [a]	Corrects the real part.
Result:	**a=** 6.	

Complex Mode Calculations

When you perform an operation, the calculator first displays the real part of the result. You can display the imaginary part by pressing [b] . Display the real part again by pressing [a] .

Example: Calculate (3 + 2i) x (3 – 4i).

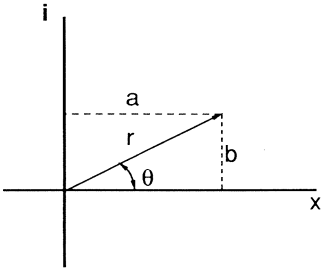
Press:	3 [a] 2 [b]
	[x] 3 [a] 4 [+/–] [b] [=]

Result:	**a=** 17.	The real part.
Press:	[*b*]	
Result:	bi= –6.	The imaginary part.

Example:	Calculate (8 – 5i) ÷ (7i).	
Press:	8 [*a*] 5 [+/–] [*b*]	
	[÷] 7 [*b*] [=]	Enter only the non-zero part of the complex number.
Result:	**a=** –0.714285714	The real part.
Press:	[*b*]	
Result:	**bi=** –1.142857143	The imaginary part.

Complex Coordinate Conversions

Complex numbers can be represented in either *rectangular* or *polar* coordinate form. So far we have used complex numbers in rectangular form.



In polar coordinates, complex numbers are usually represented using the notation (r, θ), where r and θ are respectively a constant multiplier and an imaginary exponent of the number *e*:

$$(r, \theta) = re^{\theta i}$$

The calculator enables you to easily convert between the rectangular and polar coordinate representations of a complex number.

In rectangular coordinates, the [*a*] key and the **a=** indicator identify the real part of the complex number; the [*b*] key and the **b=** indicator identify the imaginary part of the number. In polar coordinates, the [*a*] key and the **a=** indicator identify the value r, and the [*b*] key and the **b=** indicator identify θ.

CONVERTING FROM RECTANGULAR TO POLAR

Convert from rectangular coordinates to polar coordinates as follows:

- Enter the real part of the number and press [*a*] . The indicator **a=** appears at the left end of the display.
- Enter the imaginary part and press [*b*]. The indicator **b=** appears.
- Press [2ndF] [→*r*θ]. The value r is displayed immediately, with the indicator **a=**. Press [*b*] to display θ (**b=** also appears). Press [*a*] to display r again.

Before performing a complex coordinate conversion, make sure that [MODE] 1 has been selected.

Use the angular unit **DEG** in the following example.

Example: Convert the complex number 3 + 2i to the equivalent polar coordinate representation.

Press: 3 [*a*] 2 [*b*] [2ndF] [→*r*θ]

Result: **a=** 3.605551275 This is the value r.

Press: [*b*]

Result: **bi=** 33.69006753 This is θ.

This can be written (approximately) as $3.606e^{33.69i}$.

CONVERTING FROM POLAR TO RECTANGULAR

Convert from polar coordinates to rectangular coordinates as follows:

- Enter r and press [a]. **a=** appears.
- Enter θ and press [b]. **b=** appears.
- Press [2ndF] [→xy]. The real part of the number is displayed immediately, along with the indicator **a=**. Press the [b] key to display the imaginary part (**b=** also appears).

Example:	Convert $6.5e^{-4i}$ to rectangular form.	
Press:	6.5 [a] 4 [+/–] [b] [2ndF] [→xy]	
Result:	**a=** 6.484166327	The real part.
Press:	[b]	
Result:	**bi=** –0.453417079	The imaginary part.

Chapter 6:
Calculating in Statistics Mode

This chapter describes your Sharp calculator's statistical features, and explains how to use statistics mode to calculate:

- standard single-variable statistics
- probabilities from random distributions
- standard two-variable statistics
- regressions using linear, quadratic, exponential, logarithmic, power, and inverse functions

STATISTICS MODE AND OPTIONS

Enter statistics mode by pressing MODE 4. The calculator is in statistics mode when the triangle indicator points to **4:STAT** (printed above the display).
Once you are in statistics mode, the prompt **Ø ~ 6?** is displayed, asking you to select one of the seven statistics options shown below.

Option	Function	Option	Indicator
0	Single-variable statistics	**0: SD**	**ST0**
1	Linear regrssion	**1: a+bx**	**ST1**
2	Quadratic regression	**2: ..+cx²**	**ST2**
3	Exponential regression	**3: eˣ**	**ST3**
4	Logarithmic regression	**4: lnx**	**ST4**
5	Power regression	**5: axᵇ**	**ST5**
6	Inverse regression	**6: 1/x**	**ST6**

Select a statistics option as follows:

- Press the number key (0 – 6) of the option you want. While the **Ø ~ 6?** prompt is in the display, the calculator will only recognize the digit keys 0 through 6.

- When you have selected an option, the indicator for that option (given in the previous table) appears at the left end of the display.

The statistics mode and the option you're using are retained if the calculator is turned off or shuts itself off. You can exit statistics mode by pressing [MODE] 0, 1, 2, or 3.

To change the statistics option, exit statistics mode by pressing [MODE], reselect the statistics mode by pressing 4, and choose a new option by pressing the number of the option you want. Remember that when you press the [MODE] key, all previously entered statistical data and results are cleared.

THE STATISTICS KEYS

In statistics mode, the arithmetic operation keys assume secondary statistics functions in addition to their normal arithmetic functions, as follows:

- [+] assumes the second function [2ndF] [R(t)].
- [−] assumes the second function [2ndF] [Q(t)].
- [x] assumes the second function [2ndF] [P(t)].
- [÷] assumes the second function [2ndF] [t].

The independent memory keys [x→M] and [RM] each assume *two* statistical functions when the calculator is set to statistics mode, as follows:

- [x→M] assumes the first function [CD] and the second function [2ndF] [x'].
- [RM] assumes the first function [(x,y)] and the second function [2ndF] [y'].

The [M+] independent memory key assumes *one* statistical function in statistics mode: it becomes the data entry key [DATA].

STATISTICS MEMORY

The calculator stores statistical data and results in memory separately from the independent and temporary memories of the other modes. Statistical data and results are retained when the calculator is turned off or shuts itself off, but are cleared when you change modes.

The calculator's temporary and last answer memories are not available in statistics mode, and are cleared when you enter statistics mode. The independent memory is also not available. A number previously stored to the independent memory is not lost, however, and becomes available when you leave statistics mode.

CLEARING STATISTICS MEMORY

There are two ways to clear statistics memory. You can get a fresh start while using an option in statistics mode by pressing [2ndF] [CA]. This retains the selected statistics option, but erases the stored data and results.

The second way to clear statistics memory is to exit statistics mode. When you press the [MODE] key, the statistics memory is cleared. If you want to continue to use the statistics mode, you must re-enter statistics mode and select a statistics option.

Since statistical memory is retained when the calculator is turned off, it is a good idea to clear statistics memory when you turn the calculator on if statistics mode has already been selected. Do this by pressing [2ndF] [CA].

Single-Variable statistics

The calculator can quickly compute standard single-variable statistical functions and probabilities with random variables.

ENTERING SINGLE-VARIABLE DATA

Before you begin, clear the statistics memory by pressing [2ndF] [CA]. Enter data using the digit and [DATA] keys. Each time [DATA] is pressed, the calculator displays the total number of items you've entered.

The calculator automatically recalculates statistics each time you enter data. You can display intermediate values each time you enter a new data value as described in the upcoming section DISPLAYING THE RESULTS.

Example: Enter three data items: 4, 6, and 2.

Press: [MODE] 40 — Select the single-variable statistics option.

4 [DATA] 6 [DATA] 2 [DATA]

Result: **n=** 3. — Three data items have been entered.

WEIGHTED DATA (REPEATING DATA ENTRIES)

Enter repeated data as follows:

- Enter the value of the data.
- Press [x] (the multiplication key).
- Enter the number of times that value occurs.
- Press [DATA] .

Repeat this procedure for all data items.

Example: Enter the data values: 5, 9, 5, 2, 5, 9, 9, and 5. This data can be rewritten as:

Value	Number of Occurrences
2	1
5	4
9	3

Press: [MODE] 40 — Select the single-variable statistics option.

2 [DATA] 5 [x] 4 [DATA] 9 [x] 3 [DATA]

Result: **n=** 8.

CORRECTING SINGLE-VARIABLE DATA

If you make a mistake while entering data, you can correct your mistake using the clear data key [CD], as follows:

- Key in the incorrect data.
- Press [CD] . This deletes the entry from the stored statistical data, and corrects the calculated statistics.

Example:	Enter the following data: 5, 5, 5, 18, 18, 3, 3, 3, 3, 3, 3, 3.	
Press:	[MODE] 40	
	[2ndF] [CA]	Clear statistics memory.
	5 [x] 3 [DATA]	
	18 [x] 2 [DATA]	
	3 [x] 4 [DATA]	By mistake.
Result:	**n=** 9.	
	3 [x] 4 [CD]	
Result:	**n=** 5.	The four incorrect values have been deleted.
	3 [x] 7 [DATA]	To correct.
Result:	**n=** 12.	

DISPLAYING RESULTS

The calculator continually updates the statistics as you enter data. You can recall results using the [▲] and [▼] keys.
Holding down the [▲] or [▼] key performs the recall function repeatedly.

For single-variable statistics, results are recalled in the following sequence:

1. $\bar{x}$ Mean value.
2. sx Sample standard deviation (n – 1).

3. σx Population standad deviation (n).

4. n Number of data items.

5. Σx Sum of all data.

6. Σx^2 Sum of the squares.

You can search for the desired statistical result by pressing the [▲] or [▼] keys until the symbol for the statistic is displayed. Then press [=] to display the result for your data.

Example: Find the sum of the data items from the previous example.

Press:	[▲] or [▼]	Until you see Σx in the display.
	[=]	
Result:	**Σx=** 72.	

Alternatively, you can recall a statistic directly by entering its sequence number and pressing [▲] or [▼].

Example: Find the sample standard deviation sx from the example above (sx is second in the display sequence).

Press:	2	
	[▲] or [▼]	To display sx.
Result:	**sx=** 5.672902095	

COMPUTING STANDARD SINGLE-VARIABLE STATISTICS

The calculator enables you to calculate the six single variable statistics as listed in DISPLAYING THE RESULTS.

There are two standard deviation functions on the calculator: *sx* and *σx*. Use sx for the standard deviation of a *sample*. If you are sampling a population, and you wish to generalize about the population at large, you should use sx. If you are computing statistics from an *entire* population, use σx for the standard deviation.

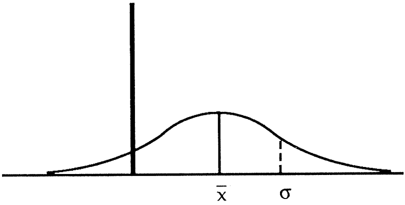
Example: What are the mean and population standard deviation of the following data? Calculate to two decimal places.

78, 92, 83, 90, 57, 95, 88, 83, 81, 85, 89

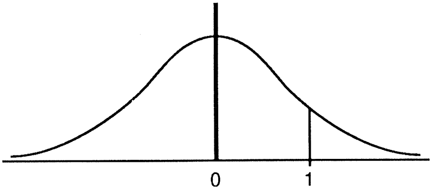
Press:	[MODE] 40	Select the single variable statistics option.
	[FSE]	Until **FIX** appears.
	[2ndF] [TAB] 2	Select 2 decimal places.
	78 [DATA] 92 [DATA] 83 [DATA] 90 [DATA] 57 [DATA] 95 [DATA] 88 [DATA] 83 [DATA] 81 [DATA] 85 [DATA] 89 [DATA]	
Result:	n= 11.00	
Press:	1 [▲]	Enter a sequence number of 1 to recall the mean.
Result:	$\bar{x}$= 83.73	The mean of the data.
Press:	3 [▲]	
Result:	σx= 9.71	Population standard deviation.

PROBABILITIES WITH RANDOM VARIABLES OF NORMAL DISTRIBUTION

The normal distribution is symmetric about its mean ($\bar{x}$), and has a "width" measured by its standard deviation (σ), as shown below.



The *standard form* of the normal distribution has a mean of 0 and a standard deviation of 1. The symbol N(0,1) is used for the standard normal form. A point along any normal distribution can be converted into an equivalent point along the N(0,1) curve.



Standard Normal Form

THE FUNCTION *T*

The *t* statistic uses the mean and standard deviation of your data to convert data values to their equivalent in the standard normal form, N (0, 1).

Use the *t* statistic to compare a single value of an x variable with your data. After you have entered your data, enter the single value and press [2ndF] [t] to see how many standard deviations that value is from the mean of your data.

Example: You have the following data:

23.45, 24.03, 22.96, 23.20, 23.67, 23.85

Is 23.16 within one standard deviation of the mean for the above data?

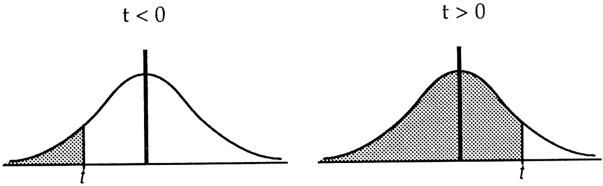
Press:	[MODE] 40	Change to the correct statistics mode and clear the statistics memory.

	[FSE]	Until the **FIX**, **SCI**, and **ENG** indicators do not show in the display.
	23.45 [DATA] 24.03 [DATA]	
	22.96 [DATA] 23.20 [DATA]	
	23.67 [DATA] 23.85 [DATA]	
	23.16 [2ndF] [t]	
Result:	−0.996628691	23.16 is within one standard deviation of the mean.

Once you have a number for *t*, you can apply the functions P(t), Q (t), and R(t) to that value.

THE FUNCTION P(T) AND PERCENTILES

The function P(t) represents the cumulative fraction of the standard normal distribution that is less than the value t. Thus, the value of P(t) corresponds to the area shaded in the following diagram:



Calculate P(t) by entering the value of *t* and pressing [2ndF] [P(t)].

Example: Calculate P(0.5).

Press: 0.5 [2ndF] [P(t)]

Result: 0.691463

A percentile is a value of P(t) that is expressed as a percent. To calculate percentiles, solve for P(t) and then multiply by 100.

Example: What percentile is the *t* value 0.5?

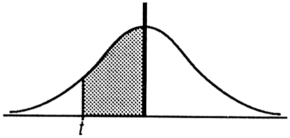
Press: 0.5 [2ndF] [P(t)] [x] 100 [=]

Result: 69.1463

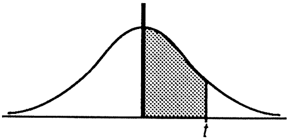
THE FUNCTION Q(T)

The function Q(t) is the cumulative fraction of the normal distribution that lies between the value *t* and 0. Thus, the value of Q(t) corresponds with the area shaded in the diagram below:

t < 0



t > 0



Calculate Q(t) by entering the value of *t* and pressing [2ndF] [Q(t)].

Example: Calculate Q(0.5).

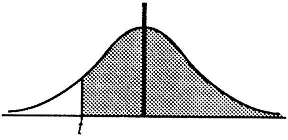
Press: 0.5 [2ndF] [Q(t)]

Result: 0.191463

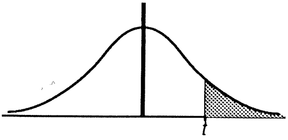
THE FUNCTION R(T)

The function R(t) is the cumulative fraction of the normal distribution that is greater than the value *t*. The value of R(t) corresponds with the area shaded in the diagram below.

t < 0



t > 0



Calculate R(t) by entering the value of *t* and pressing [2ndF] [R(t)].

Example: Calculate R(0.5).

Press: 0.5 [2ndF] [R(t)]

Result: 0.308537

Two-Variable Statistics

The calculator enables you to compute standard statistical functions for two-variable data, as well as six types of regression. The statistics options 1 to 6 shown earlier in STATISTIC MODE AND OPTIONS use two-variable data.

By selecting one of these 6 options you are selecting the type of regression you want to use.

ENTERING TWO-VARIABLE DATA

Enter data pairs as follows:

- Enter x.
- Press [(*x*,*y*)] (the *primary* function of the [RM] key in statistics mode).
- Enter y.
- Press [DATA].

As with single-variable data, you can display intermediate results before all your data is entered.

Example: Enter the following data:

x	y
500	6.38
1000	3.22
1500	3.35
2000	2.75
2500	2.87

Press: [MODE] 41 — Select the linear regression option.

500 [(x,y)] 6.38 [DATA]

1000 [(x,y)] 3.22 [DATA]

1500 [(x,y)] 3.35 [DATA]

2000 [(x,y)] 2.75 [DATA]

2500 [(x,y)] 2.87 [DATA]

Result: **n=** 5.

WEIGHTED DATA (REPEATING DATA ENTRIES)

You make repeated entries in two -variable statistics much as you do for single-variable data:

- Enter x.
- Press [(x,y)] .
- Enter y.
- Press [x] .
- Enter the number of occurrences.
- Press [DATA] .

Repeat this procedure for all data items. Notice that the display keeps a running total of the number of pairs of data items entered.

Example: Enter the following data:

x	y	Occurrences
17.4	3.7	35
19.2	4.8	48
12.6	4.2	27

Press: [MODE] 41 — Select the linear regression option.

17.4 [(x,y)] 3.7 [x] 35 [DATA]

19.2 [(x,y)] 4.8 [x] 48 [DATA]

12.6 [(x,y)] 4.2 [x] 27 [DATA]

Result: **n=** 110.

CORRECTING TWO-VARIABLE DATA

As with single-variable data, you can correct mistakes by using the [CD] key as follows:

- Enter the incorrect x value.
- Press [(x,y)].
- Enter the incorrect y value.
- Press [CD].

You can now enter the correct data.

Example: Enter the following two-variable data.

x	y	Occurrences
5	10	3
6	15	4
7	20	3

Press:		
	[MODE] 41	Selecting option 1 chooses the linear model for regression.
	5 [(x,y)] 10 [x] 3 [DATA]	
	6 [(x,y)] 15 [x] 4 [DATA]	
	7 [(x,y)] 30 [x] 3 [DATA]	A mistake!
	7 [(x,y)] 30 [x] 3 [CD]	To clear the error.

7 [(x,y)] 20 [x]
3 [DATA] The correction.

Result: **n=** 10.

DISPLAYING THE RESULTS

You can recall two-variable statistical results using the [▲] and [▼] keys just the same as with single-variable data. However, the result recalling sequence differs as follows:

For all of the regression options *except the quadratic option,* results are recalled in the following sequence:

1. a
2. b
3. r
4. $\bar{x}$
5. sx
6. σx
7. $\bar{y}$
8. sy
9. σy
10. n
11. Σx
12. Σx^2
13. Σxy
14. Σy
15. Σy^2

For the quadratic option, results are recalled in the same sequence, except number **3** is not the correlation coefficient (r), but rather it is c in the quadratic equation:

$$y = a + bx + cx^2$$

There is no correlation coefficient for quadratic regression on the calculator.

Example: Find the sum of the squares of y data (Σy^2) from the previous example.

Press: 15 Enter the sequence number that identifies Σy^2.

[▲] or [▼] To display Σy^2.

Result: $\Sigma y^2 = 2400.$

COMPUTING STANDARD TWO-VARIABLE STATISTICS

The standard two-variable statistical functions include all of the single-variable statistics plus the following:

a	a in your selected regression model equation. For example, a is the Y-intercept in the linear regression formula $y = a + bx$.
b	b in your selected regression model equation. For example, b is the slope in the linear regression formula $y = a + bx$.
r	Correlation coefficient.
c	This is a result for the quadratic model only. It is c in the equation $y = a + bx + cx^2$.
$\bar{y}$	Mean of the y values.
sy	Sample standard deviation of y values.
σy	Population standard deviation of the y values.
Σxy	Sum of the pair products xy ($= x_1y_1 + x_2y_2 + \ldots$)
Σy	Sum of the y values.
Σy^2	Sum of the squares of the y values.
x'	Calculates a predicted x for a given y using your selected regression model.
y'	Calculates a predicted y for a given x using your selected regression model.

The calculator uses linear regression formulas for exponential, logarithmic, power, and inverse regression calculations.

Entered data, x and y, are transformed into X and Y, respectively, as shown in the following table.

Type	Regression formula	Data transformation		Transformed formula
		X	Y	
Linear	$y = a + bx$	x	y	$Y = a + bX$
Exponential	$y = a \cdot e^{bx}$	x	ln y	$Y = \ln a + bX$
Logarithmic	$y = a + b \cdot \ln x$	ln x	y	$Y = a + bX$
Power	$y = a \cdot x^b$	ln x	ln y	$Y = \ln a + bX$
Inverse	$y = a + b\frac{1}{x}$	$\frac{1}{x}$	y	$Y = a + bX$

Thus, the values of $\bar{x}$, Σx, Σx^2, sx, σx, $\bar{y}$, Σy, Σy^2, Σxy, sy, and σy are determined from the transformed data (X and Y), instead of the entered data (x and y).

Correlation Coefficient

The statistic r called the *correlation coefficient* tells you how closely a particular regression equation fits your data. The correlation coefficient ranges from –1 to 1.

The correlation coefficient (r) is computed for all the regression equations except qudratic equations, available on the calculator.

Estimating Values of X or Y

Once you have entered a body of data, the calculator allows you to use that data to estimate a value of y (called y′) from a known value of x, and a value of x (called x′) from a known value of y. (Keep in mind that the estimated values x′ and y′ are only accurate if the correlation coefficient of your data is close to 1 or –1.)

Estimate y′ for a known value of x by entering x and pressing [2ndF] [y′] . Estimate x′ for a known value of y by entering y and pressing [2ndF] [x′] .

Example: Given the following data and using the linear model, determine the correlation coefficient r, and estimate y′ for x = 90, and x′ for y = 80.

x	y
82	79
53	50
61	87
74	96
51	73
51	75

Press:	$\boxed{\text{MODE}}$ 41	Select the linear regression option.
	$\boxed{\text{FSE}}$	Until **FIX** is displayed.
	$\boxed{\text{2ndF}}$ $\boxed{\text{TAB}}$ 2	For 2 decimal places.
	82 $\boxed{(x,y)}$ 79 $\boxed{\text{DATA}}$	
	53 $\boxed{(x,y)}$ 50 $\boxed{\text{DATA}}$	
	61 $\boxed{(x,y)}$ 87 $\boxed{\text{DATA}}$	
	74 $\boxed{(x,y)}$ 96 $\boxed{\text{DATA}}$	
	51 $\boxed{(x,y)}$ 73 $\boxed{\text{DATA}}$	
	51 $\boxed{(x,y)}$ 75 $\boxed{\text{DATA}}$	
Result:	**n=** 6.00	
Press:	3	
	$\boxed{\blacktriangle}$ or $\boxed{\blacktriangledown}$	
Result:	**r=** 0.55	The correlation coefficient r.

Now estimate y′ for x = 90:

Press:	90 $\boxed{\text{2ndF}}$ $\boxed{y'}$
Result:	**y=** 94.96

Estimate x′ for y = 80:

Press:	80 $\boxed{\text{2ndF}}$ $\boxed{x'}$
Result:	**x=** 67.10

REGRESSIONS

The calculator enables you to use six types of regression to compute statistics. Each regression option assumes a different relation between the independent variable x and the dependent variable y. Be sure the option you select uses a relationship that is appropriate for your particular problem.

Type of regression	Equation	Option	Mode
Linear regression	$y = a + bx$	**ST1**	MODE 41
Quadratic regression	$y = a + bx + cx^2$	**ST2**	MODE 42
Exponential regression	$y = ae^{bx}$	**ST3**	MODE 43
Logarithmic regression	$y = a + b \ln x$	**ST4**	MODE 44
Power regression	$y = ax^b$	**ST5**	MODE 45
Inverse regression	$y = a + \frac{b}{x}$	**ST6**	MODE 46

LINEAR, EXPONENTIAL, LOGARITHMIC, POWER, AND INVERSE REGRESSIONS

For all these regressions, correlation coefficient (r) is computed.

Example: Recall a and b for the previous linear model in ESTIMATING VALUES OF X OR Y.

Press: 1 Reall a.

▲ or ▼

Result: **a=** 36.17

Press: 2 Recall b.

▲ or ▼

Result: **b=** 0.65

Example: Find a, b, and correlation coefficient r for the following data using the logarithmic model. Estimate y′ for x = 70 and x = 250.

n	1	2	3	4	5	6
x	5	10	20	40	80	160
y	5.8	9.4	13.0	16.3	18.8	21.1

Two solutions may exist for the estimated y′ in the logarithmic regression. Recall each solution by pressing [2ndF] [y′].

Press: [MODE] 44 — Select the logarithmic regression option.

[FSE] — Until **FIX** is displayed.

[2ndF] [TAB] 3 — Set 3 decimal places.

5 [(x,y)] 5.8 [DATA]

10 [(x,y)] 9.4 [DATA]

20 [(x,y)] 13 [DATA]

40 [(x,y)] 16.3 [DATA]

80 [(x,y)] 18.8 [DATA]

160 [(x,y)] 21.1 [DATA]

Result: **n=** 6.000

Press: 1 — Enter the sequence number for a.

[▲] or [▼] — Recall a.

Result: **a=** –0.812

Press: 2 — Enter the sequence number for b.

[▲] or [▼]

Result: **b=** 4.452

Estimate y′ for x = 70:

Press: 70 [2ndF] [y′]

Result: **y=** 18.101

Estimate y′ for x = 250:

Press: 250 [2ndF] [y′]

Result: **y=** 23.768

QUADRATIC REGRESSIONS

No correlation coefficient (r) is computed for a quadratic regression.

Two solutions may exist for the estimated x′ in the quadratic regression. Recall the two solutions by pressing [2ndF] [x′] twice.

Example: Assuming a quadratic relationship between the x and y data below, estimate x′ for y = 6.

n	1	2	3	4	5	6
x	1	3	5	7	9	11
y	3	13	31	50	82	133

Press: [MODE] 42 — Select the quadratic regression option.

[FSE] — Until **FIX** is displayed.

[2ndF] [TAB] 6

1 [(x,y)] 3 [DATA]

3 [(x,y)] 13 [DATA]

5 [(x,y)] 31 [DATA]

7 [(x,y)] 50 [DATA]

9 [(x,y)] 82 [DATA]

11 [(x,y)] 133 [DATA]

Result: **n=** 6.000000

Estimate the two values of x′.

Press: 6 [2ndF] [x′]

Result: **x1=** 1.642739

Press: [2ndF] [x′]

Result: **x2=** –0.382969

Chapter 7: *Applications*

This chapter contains solved problems from a number of fields that demonstrate the power of your Sharp calculator.

Physics

GEOSYNCHRONOUS ORBITS

The orbit of a satellite about the earth is geosynchronous if the period of the orbit matches the period of the earth's rotation.

Example: At what distance from the center of the earth can geosynchronous orbit occur?

The period of an orbit is described by the equation:

$$T^2 = \frac{4\pi^2}{GM} r^3$$

Where:

T = Period of orbit

G = Gravitational constant

M = Mass of the earth (5.976×10^{24} kg)

r = Distance (radius) between the satellite and the center of the earth

Rearranging the equation to solve for r^3:

$$r^3 = \frac{GMT^2}{4\pi^2}$$

The earth rotates once every 23 hours, 56 minutes, and 4.09 seconds. Convert this time to seconds:

Press: 23 [D°M'S] 56 [D°M'S] 4 [D°M'S] 9 [2ndF] [→DEG] [x] 60 [x^2] [=]

Result: 86164.09 This is T.

The limiting number in your data (the mass of the earth) has only four significant digits. Select the scientific display format with **three** decimal places.

Press: [FSE] Until **SCI** appears.

[2ndF] [TAB] 3

Result: 8.616^{04}

Press: [x→M] Store this answer in M.

Solve the equation for r.

Press: 2 [CNST] [x] 5.976 [EXP] 24 [x] [RM] [x^2] [÷] [(] 4 [x] [2ndF] [π] [x^2] [)] [=]

Result: 7.499^{22} This is r^3.

Press: [2ndF] [$\sqrt[3]{\ }$]

Result: 4.217^{07} In meters.

Convert this to miles. To use the conversion to miles, you must first convert the distance to kilometers.

Press: [÷] 1000 [=] [2ndF] [CONV]

[▲] or [▼] Until km→? appears.

[→]

Result: 2.620^{04}

Geosynchronous orbit occurs at a radius of 26,200 miles from the center of the earth.

HOOKE'S LAW

Example: You have a spring that exerts a force of 25 Newtons when you compress it 0.05 meters. How much work is done by compressing it that distance?

$$\text{Work} = F{*}d = \int_0^d (F(x))\,dx.$$

For springs: $F(x) = k{*}x.$

Where:	$F(x)$ = force exerted	
	= 25 Newtons	
	x = distance the spring is compressed	
	= 0.05 meters	

Therefore: spring constant k = 25/.05

Press: 25 [÷] .05 [=]

Result: 500. K in Newtons/meter.

The integral then takes the form:

$$\int_0^{.05} (500x)\, dx.$$

Press:	[MODE] 3	Select **∫dx** mode.
	500 [x] [2ndF] [[x]] [ENT]	f(x).
	1 [EXP] 99 [+/–] [ENT]	Lower limit **a** (as close to 0 as you can get).
	.05 [ENT]	Upper limit **b**.

Using 10 subdivisions should give sufficient accuracy:

10 [ENT]

Result: **∫dx=** 0.625

TWINKLE, TWINKLE, LITTLE STAR

The **apparent magnitude** of a star tells how bright it appears. The apparent brightness of a star is determined by how far away the star is and the luminosity of the star.

Since stars are seen from greatly different distances, their luminosities must be standardized in order to be compared. This is done using a quantity called the **absolute magnitude**. The absolute magnitude of a star tells how bright that star would appear if viewed from a distance of 10 parsecs (about 32.6 light years). If the absolute magnitude of two stars is known, the ratio of their luminosities is:

$$\log \frac{L_2}{L_1} = 0.4\,(M_1 - M_2)$$

Where: M_1 = the absolute magnitude of the first star

M_2 = the absolute magnitude of the second star

L_1 = the luminosity of the first star

L_2 = the luminosity of the second star

Example: What is the ratio of the sun's luminosity to that of a star having an absolute magnitude or 2.89?

Rearranging the above equation:

$$\frac{L_2}{L_1} = 10^{.4(M_1-M_2)}$$

In this case, M_2 =2.89.

Press: .4 [x] [(] 4.8 [−] 2.89 [=] [2ndF] [10^x]

Result: 5.807644175 The star is nearly 6 times as luminous as the sun.

Example: A second star has only 0.0003 the luminosity of the sun. What is its absolute magnitude?

Rearranging the first equation to solve for M_2:

$$M2 = M1 - \frac{\log \frac{L_2}{L_1}}{0.4}$$

In this case, $\frac{L_2}{L_1}$ = .0003.

Press: 4.8 [−] [(] .0003 [log] [÷] .4 [=]

Result: 13.60719686

RADIOACTIVE DECAY

Carbon-14 (^{14}C) is a naturally occurring radioactive isotope of carbon, used in the carbon dating process. Because carbon-14 decays at a steady rate, it is possible to determine the age of a once living specimen by measuring the remaining percentage of ^{14}C it contains.

The mass of a ^{14}C contained in a sample changes according to this equation:

$M = M_0 e^{-kt}$

Where: M = Mass of ^{14}C at time t

M_0 = Original mass of ^{14}C

k = Constant of Decay
(for ^{14}C, $k = 1.2118 \times 10^{-4}$ $year^{-1}$)

t = Time in years

Example: You have a 100kg sample of ^{14}C, which you leave to decay for 10,000 years. How much ^{14}C remains? Solve for M.

Since your data is to three significant figures, select the scientific display format with two decimal places.

Press: [FSE] Until **SCI** appears.

[2ndF] [TAB] 2

100 [x] [(] 1.2118 [+/–] [EXP] 4 [+/–]

[x] 10000 [)] [2ndF] [e^x] [=]

Result: 2.98^{01} 29.8 kg.

Example: The half-life of an element is the time required for half of the mass to decay away. What is the half-life of (^{14}C)?

At the half-life of your 100kg sample, 50kg remains. This remaining mass is M in the decay equation given in the previous example. Solve for t.

$$50 \text{ kg} = 100 \text{ kg } e^{-kt}$$

$$e^{-kt} = \frac{50}{100}$$

$$-kt = \ln\left(\frac{50}{100}\right)$$

$$t = \frac{-\ln\left(\frac{50}{100}\right)}{k}$$

Press:	[( ] 50 [÷] 100 [ )] [ln] [+/–] [÷] 1.2118 [EXP] 4 [+/–] [=]	
Result:	5.72^{03}	5720 years.

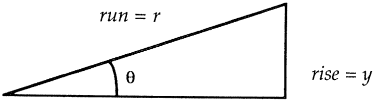
Engineering

ANGLE VS. PERCENT GRADE

Example: You have two friends who are arguing about whose street is the steeper one. One found out from the city engineer that his street was built on a 6% grade. The other measured the angle of his street to be 3 degrees. Which street is steeper?

The problem can be solved by converting either measurement into terms of the other measurement and then comparing the results. Let's convert the percent grade into degrees of angle.

Grade equals *rise over run*. Percent grade is grade times 100, (expressed as a percent). Notice that rise over run is the same as the *sin* of the angle.



$$\text{SIN}(\theta) = \frac{y}{r} = \frac{\text{rise}}{\text{run}}$$

The equation is:

$$\text{SIN}(\theta) = 6\%$$

or: $\theta = \text{SIN}^{-1}(6\%)$

Use the [2ndF] [%] key when entering percent values. Make sure **DEG** is selected. To convert a 6% grade to degrees:

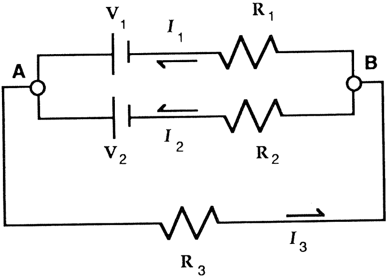
Press: 6 [2ndF] [%] [2ndF] [$\sin^{-1}$]

Result: 3.439812768 degrees

The 6% grade can be rounded to a 3.44° angle. It is the steeper street. Your friends can stop arguing.

ELECTRIC CIRCUIT (KIRCHHOFF'S LAWS)

Example: What are the currents (I_1, I_2, I_3) in this circuit?



Given that the components of the circuit have the values:

$V_1 = 8$ volts

$V_2 = 4$ volts

$R_1 = 5$ ohms

$R_2 = 2$ ohms

$R_3 = 2$ ohms

Kirchhoff's Law for circuit junctions states that the sum of the currents entering a junction must be the same as the sum of the currents leaving the junction. In this example, at junction A,

$I_1 + I_2 - I_3 = 0$ (equation 1)

Kirchhoff's Law for a closed circuit states that the sum of the voltage changes around any closed circuit must equal zero. Taking the closed loop that includes V_1 and R_3:

$V_1 - I_1R_1 - I_3R_3 = 0$

or: $I_1R_1 + I_3R_3 = V_1$ (equation 2)

Around the closed loop that includes V_2 and R_3:

$$V_2 - I_2R_2 - I_3R_3 = 0$$

or: $$I_2R_2 + I_3R_3 = V_2 \qquad \text{(equation 3)}$$

Grouping equations 1, 2, and 3 and substituting known voltages and resistances gives:

$$I_1 + I_2 - I_3 = 0$$

$$5I_1 + 2I_3 = 8$$

$$2I_2 + 2I_3 = 4$$

We now have three equations containing three unknowns. The calculator's **3–VLE** mode can solve this system of equations quickly.

Press: [MODE] 2

Press: 1 [ENT] 1 [ENT] 1 [+/–] [ENT] 0 [ENT]

5 [ENT] 0 [ENT] 2 [ENT] 8 [ENT]

0 [ENT] 2 [ENT] 2 [ENT] 4 [ENT]

Result: **x=** 1 — The value of I_1.

Press: [ENT]

Result: **y=** 0.5 — The value of I_2.

Press: [ENT]

Result: **z=** 1.5 — The value of I_3.

SELECTING CHARACTERS FOR A RUDIMENTARY COMPUTER

You own a very simple computer. You can display any character by entering that character's code as a hexadecimal number.

The decimal code for letter characters is determined by adding 196 to the number of the letter's place in the alphabet. The code for *a* would then be 196 + 1 = 197, the code for the 23rd letter of the alphabet would be 196 + 23 = 219, and so forth. Once the decimal code is determined, it must be converted to hexadecimal.

Example: What codes correspond to the letters r and y?

The letter r is the 18th letter of the alphabet.

Press:	[MODE] [ON/C]	To place in normal mode.
Press:	[2ndF] [→DEC]	Select **DEC** mode.
	196 [+] 18 [=]	
Result:	214.	
	[2ndF] [→HEX]	Convert to **HEX**.
Result:	d6.	

Example: What is the code for y?

Press:	[2ndF] [→DEC]	Select **DEC** mode.
	196 [+] 25 [=]	
Result:	221.	
	[2ndF] [→HEX]	Convert to **HEX**.
Result:	dd.	

On this computer, the codes for capital letters are found by subtracting the hexadecimal number 20 from the code for the equivalent lower case letter.

Example: What is the code for Y?

Press:	[2ndF] [→HEX]	Select **HEX** mode.
	dd [−] 20 [=]	
Result:	bd.	In hexadecimal.

Statistics

CHI-SQUARE TEST

The chi-square test (χ^2) compares a sample of data to a statistical hypothesis (probability distribution). The chi-square is a "goodness of fit" test that is applicable to nominal scale data (discrete functions). The data are tallies of observations in categories.

To perform the chi-square test, observed values from an experiment are compared to the expected values based on the probability model. The following statistic is calculated and compared to a table of chi- square critical values:

$$\chi^2 = \sum \frac{(f_i - F_i)^2}{F_i} \quad \text{or,} \quad \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

Where: f_i = number of observations for category i

F_i = expected number of observations for category i (based on the statistical model)

Example: You have been culturing a plant with flowers of types P, Q, R, and S. According to Mendel's Laws, the number of each type should conform to the ratio of 9:3:3:1. In your experiment, the results are:

Flower Type:	P	Q	R	S	
Probability Model:	9	3	3	1	= 16
Expected Ratio:	$\frac{9}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{16}$	
# Observed:	125	40	42	12	= 219

You want to know if the flowers you have been culturing conform to Mendel's probability model.

This is an analysis of single-variable data. Begin by entering the single-variable option in statistics mode.

Press: $\boxed{\text{MODE}}$ 40 — To enter statistics mode, single-variable option.

You can compute the expected number of flowers in each flower type (F_i) by multiplying the expected ratio for that type by the total number of flowers.

Press:	9 [÷] 16 [x] 219 [=]	
Result:	123.1875	Expected number for Type P.
Press:	3 [÷] 16 [x] 219 [=]	
Result:	41.0625	Expected number for Types Q and R.
Press:	1 [÷] 16 [x] 219 [=]	
Result:	13.6875	Expected number for Type S.

The chi-squared statistic is easily computed in statistics mode. For each flower type (P through S), use the arithmetic operation keys to compute

$$\frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

and enter it as a data item. The chi-squared statistic is the sum of these (Σx) for the four flower types.

Press:	125 [−] 123.1875 [=] [x^2] [÷] 123.1875 [=] [DATA]	
	40 [−] 41.0625 [=] [x^2] [÷] 41.0625 [=] [DATA]	
	42 [−] 41.0625 [=] [x^2] [÷] 41.0625 [=] [DATA]	
	12 [−] 13.6875 [=] [x^2] [÷] 13.6875 [=] [DATA]	
	5 [▲] or [▼]	To recall the sum of x values.
Result:	Σx= 0.283612379	

Compare this calculated chi-squared with critical values from a standard chi-squared table. The number of *degrees of freedom* is equal to the number of data categories minus 1. The number of categories in this example is 4 (the number of flower types), so the degrees of freedom is 3.

The critical value of chi-squared from the table (95% level of confidence, 3 degrees of freedom) is 7.81. Since your calculated answer is less than this critical value, your experimental results agree with the hypothesis and suggest that your flowers conform to Mendel's probability model.

REGRESSION

The calculator's six regression options enable you to test hypotheses for two-variable data.

Example: In your grocery business, you stock three different colors of apples: red, yellow, and green.

Red apples cost 17.4¢ per pound, and you can display 35 pounds. Green apples cost 19.2¢ per pound, and you can display 48 pounds. Yellow apples cost 12.6¢ per pound, and you can display 27 pounds.

Red apples have been averaging 3.7 apples per pound. Green apples have been averaging about 4.8 apples per pound. Yellow apples have been averaging about 4.2 apples per pound.

What is your average cost per pound of displayed apples ($\bar{x}$) and how many apples do you display?

This is a two-variable statistical problem that assumes a linear relationship between x and y. Key in the cost per pound as x, the apples per pound as y, and the number of displayed pounds as the number of occurrences.

Press:	[MODE] 41	Select the linear regression option.
	17.4 [(x,y)] 3.7 [x] 35 [DATA]	
	19.2 [(x,y)] 4.8 [x] 48 [DATA]	

12.6 [(x,y)] 4.2 [x] 27 [DATA]

Result: **n=** 110.

As you key this data in, the number n in the display reflects the total number of pounds. After you have the data keyed in, you can obtain the average price per pound of displayed apples.

Press: 4 [▲] or [▼] Recall $\bar{x}$.

Result: **$\bar{x}$=** 17.00727273

You can obtain the number of displayed apples by multiplying the average apples per displayed pound $\bar{y}$ by the number of displayed pounds n.

Press: 7 [▲] or [▼] Recall $\bar{y}$.

Result: **$\bar{y}$=** 4.302727273

[x] 110 [=]

473.3

This means you usually display between 473 and 474 apples in your store.

Business and Money

BANK INTEREST

The formula for determining the future value of an investment earning a fixed rate of interest is:

$$FV = PV\,(1 + i)^n$$

Where: FV = Future value

PV = Present value

i = interest rate per period (expressed as a fraction)

n = number of periods

Example: You invest $5,000 in a 4-year note that pays 9 percent interest, compounded quarterly. What is its value after the 4 years?

Set the calculator for two decimal places (since dollars are only calculated to two decimal places).

Press: [FSE] Until **FIX** appears.

[2ndF] [TAB] 2

The total number of periods can be calculated from the number of periods per year (4) and the number of years (4).

$$n = 4 \text{ years} \times \frac{4 \text{ periods}}{\text{year}}$$

$$i = \frac{9\%}{\text{year}} \times \frac{1 \text{ year}}{4 \text{ periods}}$$

The interest rate per period calculation becomes:

$$FV = 5000\ (1 + \frac{9\%}{4})^{4\times4}$$

Press: 5000 [x] [(] 1 [+] 9 [2ndF] [%] [÷] 4 [)] [y^x] [(] 4 [x] 4 [)] [=]

Result: 7138.11

What would the value be if it were compounded daily?

This time:

$$n = 4 \text{ years} \times \frac{365 \text{ days}}{\text{year}}$$

$$i = \frac{9\%}{365}$$

Press: 5000 [x] [(] 1 [+] 9 [2ndF] [%] [÷] 365 [)] [y^x] [(] 4 [x] 365 [)] [=]

Result: 7166.33

Fun and Games

Drive My Car

Example: The gas tank of your European car holds 46.2 liters. If gas costs $.91 per gallon, how much will it cost to fill your tank?

Press: [FSE] — Until **FIX** appears.

[2ndF] [TAB] 2

Press: .91 [x] 46.2 [2ndF] [CONV]

[▲] or [▼] — Until $\ell \rightarrow ^{?}$ appears.

[→] [=]

Result: 11.11 — It will cost $11.11 to completely fill your tank.

Example: It will take you 13 hours and 36 minutes to drive from San Fransisco to Portland. If you want to break the trip into three legs of equal length, how long should each leg be?

Press: 13 [D°M'S] 36 [÷] 3 [=]

Result: 4°32′00.00 — 4 hours and 32 minutes.

The Lottery

Example: The state you live in has two different lotteries. In the first, you must pick 6 digits between 1 and 50, in any order. In the second, you have to pick 5 digits between 1 and 35, but you must pick them in the correct order. Which lottery gives you a better chance of winning?

For the first lottery, your chances of winning are 1 in $_{50}C_{6}$:

Press: 50 [*nCr*] 6 [=]

Result: 15890700.

Your chances of winning the second lottery are 1 in ${}_{35}P_5$:

Press: 35 [2ndF] [nPr] 5 [=]

Result: 38955840.

Your chances are better in the first lottery.

Appendix A: *Physical Constants and Metric Conversions*

PHYSICAL CONSTANTS

Recall a physical constant by entering the number of the constant from the table below, and pressing [CNST], or by pressing [CNST] and scrolling through the list using the [▲] and [▼] keys.

(The physical constants registered in this calculator are the adjusted values from the CODATA (Committee on Data for Science and Technology) of ICSU (International Council of Scientific Unions) of 1986.)

Constant	Symbol	Value
1. Speed of light in vacuum	c	2.99792458×10^{8} m/sec
2. Gravitational constant	G	6.67259×10^{-11} N•m^2/kg^2
3. Gravitational acceleration	g	9.80665 m/s^2
4. Electron mass	m_e	$9.1093897 \times 10^{-31}$ kg
5. Proton mass	m_p	$1.6726231 \times 10^{-27}$ kg
6. Neutron mass	m_n	$1.6749286 \times 10^{-27}$ kg
7. Atomic mass unit	u	$1.6605402 \times 10^{-27}$ kg
8. Electron charge	e	$1.60217733 \times 10^{-19}$ C
9. Planck constant	h	$6.6260755 \times 10^{-34}$ J•s
10. Boltzmann constant	k	1.380658×10^{-23} J/k
11. Magnetic permeability	μ_0	$1.2566370614 \times 10^{-6}$ H/m
12. Dielectric permittivity	ε_0	$8.854187817 \times 10^{-12}$ F/m
13. Classical electron radius	r_e	$2.81794092 \times 10^{-15}$ m
14. Fine structure constant	α	$7.29735308 \times 10^{-3}$
15. Bohr radius	a_0	$5.29177249 \times 10^{-11}$ m

	Constant	Symbol	Value
16.	Rydberg constant	R_∞	$1.0973731534 \times 10^{7}$ m^{-1}
17.	Flux quantum	Φ_0	$2.06783461 \times 10^{-15}$ Wb
18.	Bohr magneton	μ_B	$9.2740154 \times 10^{-24}$ J/T
19.	Electron magnet moment	μ_e	$9.2847701 \times 10^{-24}$ J/T
20.	Nuclear magneton	μ_N	$5.0507866 \times 10^{-27}$ J/T
21.	Proton magnetic moment	μ_P	$1.41060761 \times 10^{-26}$ J/T
22.	Neutron magnetic moment	μ_n	$9.6623707 \times 10^{-27}$ J/T
23.	Compton electron wavelength	λ_c	$2.42631058 \times 10^{-12}$ m
24.	Compton proton wavelength	λ_{cp}	$1.32141002 \times 10^{-15}$ m
25.	Stefan-Boltzmann constant	σ	5.67051×10^{-8} W/m^2K^4
26.	Avogadro's constant	N_A	6.0221367×10^{23} mol^{-1}
27.	Ideal gas volume at STP	V_m	2.24141×10^{-2} m^3/mol
28.	Gas constant	R	8.31451 J/mol•K
29.	Faraday constant	F	9.6485309×10^{4} C/mol
30.	Quantum hole resistance	R_H	$2.58128056 \times 10^{4}\Omega$

METRIC CONVERSIONS

Recall a metric conversion by pressing 2ndF CNST and scrolling through the list using the ▲ and ▼ keys. Carry out the conversion by pressing the → key.

1.	inches → centimeters	1 inch	=	2.54 centimeters
2.	centimeters → inches			
3.	feet → meters	1 foot	=	0.3048 meters
4.	meters → feet			
5.	yards → meters	1 yard	=	0.9144 meters
6.	meters → yards			
7.	miles → kilometers	1 mile	=	1.609344 kilometers
8.	kilometers → miles			
9.	ounces → grams	1 ounce	=	28.349523125 grams
10.	grams → ounces			
11.	pounds → kilograms	1 pound	=	0.45359237 kilograms
12.	kilograms → pounds			
13.	°F → °C	°F	=	$1.8 \times$ °C + 32
14.	°C → °F			
15.	U.S. gallons → liters	1 gallon	=	3.785411784 liters
16.	liters → U.S. gallons			
17.	Joules → calories	1 Joule	=	0.238920081232 calories
18.	calories → Joules			
19.	horsepower → kilowatts	1 hp	=	0.745699871582 kW
20.	kilowatts → horsepower			

Appendix B: *Calculation Ranges and Error Conditions*

In general, your Sharp calculator produces every reasonable calculation given a 10-digit accuracy and 2-digit limit for exponents. The calculator can display integers between –9999999999 and 9999999999.

Real numbers can be displayed to a precision of 10 digits, so that $1 \times 10^{-99} \leq |x| \leq 9.999999999 \times 10^{99}$. Numbers less than 1×10^{-99} are considered equal to 0.

You can not enter numbers that exceed the limits of the display. When the display is full, the calculator ignores any additional digits.

FUNCTION RANGES

Numbers used as input must be within the range of the given function (under the usual definition of the function). The range for each of the calculator's functions is given in the following pages.

Function	Range
$\sin x$ $\cos x$ $\tan x$	DEG: $\lvert x \rvert < 1 \times 10^{10}$ RAD: $\lvert x \rvert < \frac{\pi}{180} \times 10^{10}$ GRAD: $\lvert x \rvert < \frac{10}{9} \times 10^{10}$ With tan x, however, an error occurs in the following cases: DEG: $\lvert x \rvert = 90\ (2n - 1)$ RAD: $\lvert x \rvert = \frac{\pi}{2}\ (2n - 1)$ GRAD: $\lvert x \rvert = 100\ (2n - 1)$ (n is an integer)
$\sin^{-1} x$ $\cos^{-1} x$	$-1 \le x \le 1$
$\tan^{-1} x$	$\lvert x \rvert < 1 \times 10^{100}$
$\ln x$ $\log x$	$1 \times 10^{-99} \le x < 1 \times 10^{100}$
e^x	$-1 \times 10^{100} < x \le 230.2585092$
10^x	$-1 \times 10^{100} < x < 100$
y^x	$y > 0$: $-1 \times 10^{100} < x \log y < 100$ $y = 0$: $0 < x < 1 \times 10^{100}$ $y < 0$: $-1 \times 10^{100} < x \log \lvert y \rvert < 100$ where x is an integer or 1/x is an odd number ($x \neq 0$)

Function	Range
$\sqrt[x]{y}$	y > 0: $-1 \times 10^{100} < \frac{1}{x} \log y < 100 \quad (x \neq 0)$ y = 0: $0 < x < 1 \times 10^{100}$ y < 0: $-1 \times 10^{100} < \frac{1}{x} \log \lvert y \rvert < 100$ where x is an odd number or 1/x is an integer $(x \neq 0)$
sinh x cosh x tanh x	$\lvert x \rvert \leq 230.2585092$
$\sinh^{-1} x$	$\lvert x \rvert < 1 \times 10^{50}$
$\cosh^{-1} x$	$1 \leq x < 1 \times 10^{50}$
$\tanh^{-1} x$	$\lvert x \rvert < 1$
$\sqrt{x}$	$0 \leq x < 1 \times 10^{100}$
$\sqrt[3]{x}$	$\lvert x \rvert < 1 \times 10^{100}$
x^2	$\lvert x \rvert < 1 \times 10^{50}$
$\frac{1}{x}$	$\lvert x \rvert < 1 \times 10^{100} \ (x \neq 0)$
n!	$0 \leq n \leq 69$ (n is an integer)
nPr	$0 \leq r \leq n \leq 9999999999$ (n, r are integers) $\frac{n!}{(n-r)!} < 1 \times 10^{100}$

<table>
<tr><th>Function</th><th>Range</th></tr>
<tr><td>nCr</td><td>$0 \leq n \leq 9999999999$
(n, r are integers)
$0 \leq r \leq 69$
$r \leq n$
$\frac{n!}{(n-r)!} < 1 \times 10^{100}$</td></tr>
<tr><td>→DEG</td><td>$0°00'00.01 \leq | x | \leq 10000°$</td></tr>
<tr><td colspan="2">(D M'S and sexagesimal calculations). If $| x |$ is less than 0°00'00.01, it is treated as zero in calculations.</td></tr>
<tr><td>$x, y \rightarrow r, \theta$</td><td>$| x | < 1 \times 10^{50}$, $| y | < 1 \times 10^{50}$
$x^2 + y^2 < 1 \times 10^{100}$
$\left| \frac{y}{x} \right| < 1 \times 10^{100}$</td></tr>
<tr><td>$r, \theta \rightarrow x, y$</td><td>$0 \leq r < 1 \times 10^{100}$
θ has the same restrictions as for trigonometric functions.</td></tr>
<tr><td>DRG▶</td><td>DEG → RAD: $| x | < 1 \times 10^{100}$
RAD → GRAD: $| x | \leq 1.570796326 \times 10^{98}$
GRAD → DEG: $| x | < 1 \times 10^{100}$</td></tr>
<tr><td colspan="2">Complex Numbers
For (A + Bi) and (C + Di):
Addition: $| A \pm C | < 1 \times 10^{100}$
Subtraction: $| B \pm D | < 1 \times 10^{100}$
Multiplication: $| x | < 1 \times 10^{100}$
where x is the result or intermediate result of calculation (AC – BD) or (AD + BC).</td></tr>
</table>

Function	Range	
Complex Numbers (contd)		
Division:	$\mid x \mid < 1 \times 10^{100}$ $(C^2 + D^2 \neq 0)$	
	where x: result or intermediate result of calculation	
	$(AC + BD)/(C^2 + D^2)$ or	
	$(BC - AD)/(C^2 + D^2)$	
Conversions	Converted result:	
→DEC	DEC:	$\mid x \mid \leq 9999999999$
→BIN	BIN:	$1000000000 \leq x \leq 1111111111$
		$0 \leq x \leq 111111111$
→OCT	OCT:	$4000000000 \leq x \leq 7777777777$
		$0 \leq x \leq 3777777777$
→HEX	HEX:	FDABF41C01 $\leq x \leq$ FFFFFFFFFF
		$0 \leq x \leq$ 2540BE3FF
Bin/Oct/Hex number operations		
NOT	BIN:	$1000000000 \leq x \leq 1111111111$
		$0 \leq x \leq 111111111$
	OCT:	$4000000000 \leq x \leq 7777777777$
		$0 \leq x \leq 3777777777$
	HEX:	FDABF41C01 $\leq x \leq$ FFFFFFFFFF
		$0 \leq x \leq$ 2540BE3FE
NEG	BIN:	$1000000001 \leq x \leq 1111111111$
		$0 \leq x \leq 111111111$
	OCT:	$4000000001 \leq x \leq 7777777777$
		$0 \leq x \leq 3777777777$
	HEX:	FDABF41C01 $\leq x \leq$ FFFFFFFFFF
		$0 \leq x \leq$ 2540BE3FF

Function	Range
Others	The ranges for entries and results in each mode are as for "conversion" above.
3-VLE: the absolute values of the final and intermediate results must be smaller than 1×10^{100}. The determinant must not be zero.	
Integration	Integration interval [a, b]: $-1 \times 10^{100} < a < b < 1 \times 10^{100}$ where $\lvert a - b \rvert < 1 \times 10^{100}$ Subdivisions n: $1 \leq n \leq 4999999999$ (n is an integer) The absolute values of the final and intermediate results of calculation must also be less than 1×10^{100}.

Statistical Calculations: the absolute value of the final and intermediate results must be less than 1×10^{100}.

INTERMEDIATE CALCULATIONS

Some of the functions calculate intermediate results before the final answer is displayed. The intermediate calculations must stay within the same limits as the final results.

Error Conditions

An error results under the following conditions:

- when the absolute value of a calculation is equal to or greater than 1×10^{100}.
- when a number is divided by zero
- when more than four operations are pending in normal mode, or more than one in statistics or 3-VLE mode.
- when the [( ] key is use more than 15 times in a single expression.
- when an operation outside the legal calculation range is attempted.
- when you attempt to enter more than 23 steps for function f(x) in ∫**dx** mode.
- when a number other than the positive integers 1 through 30 is entered and [CNST] is pressed.

If any of the above errors occurs, the error indicator "-E-" appears in the left end of the display.

Press the [ON/C] key to clear the error.

Appendix C: *Taking Care of Your Calculator*

Care

To ensure trouble-free operation of your Sharp calculator, keep the following points in mind when using your calculator:

- Keep your calculator out of direct sunlight and away from high temperatures.
- Keep your calculator away from rapid temperature changes, moisture, and dust.
- Your calculator's display is made from a liquid crystal sealed between two glass plates. Avoid dropping or jarring the calculator, and do not carry it in your back pants pocket.
- Clean your calculator with a soft, dry cloth. Do not use water or solvents.
- Do not leave the batteries in your calculator if you will not be using it for an extended period.
- If your calculator needs service, use only an authorized Sharp Service Center.
- Keep this manual for reference.
- Built-in self-test: With calculator off, press and hold: $\boxed{2ndF}$ $\boxed{D}$ $\boxed{ON/C}$ then release.

Batteries

The calculator uses two alkaline-manganese batteries (model LR44) for power. If the indicators and numbers in the display appear dim, the batteries should be replaced as soon as possible.

EL-557 uses LR54
= LR1130
= LR1131

How to Replace the Battery

1. Press the $\boxed{\text{OFF}}$ key to turn off the calculator.
2. Remove the two screws holding the back cover of the calculator, and remove the cover.
3. Remove the used batteries from the battery compartment by prying with a ball point pen or similar instrument.
4. Install two fresh batteries (model LR44 or equivalent) with their positive (+) sides facing out of the calculator.
5. Replace the battery cover and secure it with the screws.
6. Once the batteries have been replaced, the display should read **OK**. If not, remove the batteries and install them again.
7. After **OK**. appears in the display, press any key to initialize the calculator.

Hints on Battery Use

- Use only type LR44 (or equivalent) alkaline-manganese batteries.
- Replace both batteries at the same time. Do not mix new and used batteries.
- Be sure the batteries are installed with their positive terminals facing out of the calculator.

Cautions

- Keep batteries out of reach of children.
- Dispose of the old battery in a safe place. The battery may explode if disposed of in a fire.
- To avoid damage by corrosive leakage, remove the battery when it is worn out or when the calculator is to be stored for a long period of time.

Appendix D: *Specifications*

Model:	EL-506D = small version of EL-557
Display capacity:	Floating-point display: 10 digits. Exponent display: Mantissa: 10 digits Exponent: 2 digits
Calculations:	4 basic arithmetic calculations, constant calculations, memory calculations, decimal/sexagesimal conversions, sexagesimal calculations, trigonometric and inverse trigonometric functions, logarithmic functions, exponential functions, square and power functions, square root, cube root, power root, reciprocal, factorial, coordinates conversion, hyperbolic and inverse hyperbolic functions, percent, complex number calculations, binary/octal/hexadecimal calculations, logical operations, permutations, combinations, simultaneous linear equations with three unknowns, integrations, metric conversions, physical constants, statistical calculations.
Component:	LSI, etc.
Display type:	Liquid crystal (FEM type)
Power supply:	3V DC from 2 alkaline-manganese batteries (model LR44) EL-557 uses LR54.
Power consumption:	0.0006W

Life of battery:	LR44: Approx.1300 hours while displaying 55555. at 20°C (68°F) (The operating time can vary depending on the type of the battery or usage.) (Batteries are factory installed before shipment. They may require replacement in less than 1300 hours.)
Operating temperature:	0°C to 40°C (32°F to 104°F)
Dimensions:	69 x 128 x 7.5 mm (2-23/32 x 5-1/32 x 9/32 inch) (without wallet)
Weight:	82 g (0.18 lb) (with batteries and wallet)
Accessories:	Two LR44 alkaline-manganese batteries (installed), Operation Manual.

Appendix E: *Function Count*

MATHEMATICAL FUNCTIONS

Function Type	Functions	Count
Trigonometric	sin, cos, tan (for each angular unit)	9
Inverse Trigonometric	$\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$ (for each angular unit)	9
Exponential & Logarithmic	e^x, 10^x, In, log	4
Power, Root	y^x, $\sqrt[x]{y}$	2
Algebraic	x^2, $\sqrt{\ }$, $\sqrt[3]{\ }$, $\frac{1}{x}$	4
Hyperbolic	sinh, cosh, tanh	3
Inverse Hyperbolic	$\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$	3
Angular Units	DEG, RAD, GRAD, angular unit conversions (DEG ↔ RAD, DEG ↔ GRAD, RAD ↔ GRAD)	9
Degree Conversions	▸DMS, ▸DEG	2
Coordinate Conversions	▸rθ, ▸xy	2
Number Base Conversions	DEC ↔ BIN, DEC ↔ OCT, DEC ↔ HEX, BIN ↔ OCT, BIN ↔ HEX, OCT ↔ HEX	12
Change Base Calculating	HEX, OCT, BIN, HEG (+/–)	4
Complex Number Calculations	+, –, x, ÷, rθ ↔ xy	6
Statistics:		
One-variable	n, Σx, Σx^2, $\bar{x}$, σx ,sx	6
Two-variable	Σy, Σy^2, Σxy, $\bar{y}$, σy, sy	6

Function Type	Functions	Count
Linear Regression	r, a, b, a, b, c (quadratic), r, a, b (exponential, power, logarithmic, inverse)	18
Estimation	x′, y′	2
Probability	t, P(t), Q(t), R(t)	4
Others	CD, DATA	2
Modify	MDF	1
Factorial	n!	1
Permutations, Combinations	nPr, nCr	2
Percent	%, +%, −%, x%, +%	5
Random Number	RANDOM	1
Simultaneous Linear Equations	3–VLE, determninant	2
Integration	∫dx, n, interval [a,b]	3
Sexagesimal Calculations	+, −, x, ÷, constant calculation, X▸M, RM, M+	11
Logical Operations	NOT, AND, OR, XOR, XNOR	5
Constant Calculations	y^x, $\sqrt[x]{y}$	2
Priority Levels	15 levels of ( ), 4 pending operations	20
Display Format	FIX, SCI, ENG, TAB (0–9)	13
Data Entry	π, EXP, 30 physical constants	32
Metric Conversions		20
Total Scientific Functions		225

Calculator Functions

Function Type	Functions	Count
Clear, Edit	C, CE, CA, →, ▲, ▼	6
Arithmetic	+, −, x, ÷	4
Independent memory	X▶M, RM, M+	3
Temporary memory	M_1 to M_7	7
Last Answer Memory	ANS	1
Negative Number Entry	+/−	1
Constant Calculation	+, −, x, ÷	4
Exchange	$x \leftrightarrow y$	1
Total Calculator Functions		27
Total Functions		252

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