What to look for before you buy an advanced calculator.



DISPLAY

- Editing:
 Program review—backs
- Program review-single
- Dinsert/Delete
- Overwrite
- Direct branching
- D PAUSE
- Conditional tests
- □ Flags
- DSZ (looping)
- □ Subroutines





FUNCTIONS



ACCESSORIES



LOGIC SYSTEMS



VALUE



FEATURES



SERVICE & WARRANTY



PHYSICAL CONSTRUCTION



MANUFACTURER'S REPUTATION



Foreword

More and more people are discovering that an advanced calculator offers unprecedented computational power. Students, accountants, salespersons, realtors and professionals in many fields are using them to solve complex or repetitious problems. Businesses are using them to keep track of finances; pilots, to plot courses; scientists, to analyze experimental results: surveyors, to calculate distances; and engineers, to complete designs. The American astronauts of the 1975 Apollo-Sovuz space rendezvous even used a calculator to back up their on-board computer system!

Calculators have come a long way since they were introduced in 1971. Then, machines sold for several hundred dollars and were only capable of basic arithmetic addition, subtraction, multiplication, division. Now, machines perform such specialized operations as computing the tangent of an angle or the power of a number in a single keystroke. Some can even be programmed like a computer.

If a basic calculator will meet your mathematical needs, you should have little trouble selecting from the multitude of inexpensive machines on the market.

However, if you're thinking about buying an advanced calculator, your decision is considerably more difficult. In order to make an intelligent purchase, you'll need to know just what kind of machine you need, what features and functions are most important for your use. how to compare different models. That's why this book exists: to provide basic information about advanced calculators and how they operate so that you will know what to look for-before you buy.

^{©1976} Approach 13-30 Corporation, 1005 Maryville Pike, Knoxville, TN 37920. All rights reserved.

Contents



2 Introducing: The Range of Advanced Calculators

- 14 Those Amazing Programmables
- **4** Communicating with a Calculator
- 8 Functions, Memories, Features– Know What You Need
- 18 How To Compare Calculator Construction
- **20** The Choice Is Yours



Introducing: The Range of Advanced Calculators

At first glance, a display case full of advanced calculators presents a confusing array of incredibly diverse machines. Actually, though, all advanced calculators can be classified as either preprogrammed or programmable problem solvers.

Preprogrammed calculators have specialized mathematical operations built into the machine. There are two basic kinds of preprogrammed machines: those which feature scientific operations and those which feature business operations.

Programmable calculators have a number of preprogrammed operations, but in addition they can "learn" how to solve complex or repetitious problems in a variety of fields quickly and efficiently.

Preprogrammed Scientific Calculators

Despite the classification, advanced scientific calculators are employed by members of such diverse fields and professions as biology, mathematics, agriculture, navigation, astronomy, aviation and meteorology. They are particularly popular with both engineers and engineering students, many of whom have replaced the traditional slide rule with considerably more accurate and versatile pocket-size calculators.

The typical scientific calculator derives logarithms and trigonometric functions far faster than a slide rule—and with 10-digit accuracy. It can calculate angles in either radians or degrees; its ability to extract roots or raise numbers to a power is limited only by the capacity of its display; and it offers such specialized features as pi displayed to 10-digit accuracy with a single keystroke, rectangular-to-polar coordinate conversion, and statistical functions.

Preprogrammed Business Calculators

Advanced business calculators are capable of solving many of the mathematical problems encountered in the world of commerce. Students use them in a variety of business courses. Loan officers and salespersons use them to compute the payments on a note far faster and with much greater accuracy than by referring to a book of tables. Brokers and statisticians use them to evaluate data, analyze trends and make forecasts. And managers use them to help make fast and accurate financial decisions in today's fast-paced economy.

The typical business calculator includes a range of special purpose keys for such financial data as interest rate, payment period, payment amount, present value and future value. It also includes several useful statistical functions, at least one memory and 10-digit accuracy.

Programmable Calculators

While scientific and business calculators are designed to solve specific types of problems, programmable calculators can be easily taught—or programmed—by their user to solve problems in virtually *any* field. They can also be programmed to solve a long series of problems which use the same basic formula or equation much faster than you could key each individual problem into the calculator. In addition, all programmable calculators can be operated like conventional preprogrammed machines by simply pushing a switch or key.

Fortunately, you don't need a knowledge of programming to take advantage of these computer-like capabilities. Most manufacturers supply a variety of programs (software in the jargon of the computer user) which can be used by even a novice. And since programs for programmable calculators are nothing more than listings of keystrokes you would use to solve problems manually, anyone can soon become an adept and skillful programmer.



Communicating with a Calculator

In order to use any calculator, you must first learn how to communicate with it. There are two calculator "languages"—algebraic entry and RPN—so you'll want to explore each before making a purchase.

The only technical difference between algebraic entry and RPN is the order in which the four arithmetic function keys are pressed. Calculators designated as algebraic place the arithmetic function between the numbers of two-number operations (e.g. two times two). In contrast, RPN machines place the arithmetic function after both members of a twonumber operation are entered into the machine (e.g. two and two multiplied). Both entry languages process single-number operations using RPN (e.g. two squared).

To give you an example, the two-number operation 4 + 8 = 12 is entered into an algebraic calculator precisely as it appears printed in this sentence. You simply enter 4, press the + key, enter 8 and hit the = key. The display flashes the correct answer: 12.

With RPN, the same problem is solved by pressing 4, pressing an <u>ENTER</u> key (also often designated as +), pressing 8 and hitting the + key. Again, the correct answer appears in the display: 12.

Algebraic entry takes the same format as the arithmetic you learned in grammar school and thus initially appears easier to learn. The basics of either language can be mastered quickly, though, so you'll want to make a thorough comparison of the advantages and disadvantages of machines using both languages.

More About Algebraic and RPN

There are several different kinds of algebraic entry. Any algebraic or RPN machine can easily solve simple problems in addition, subtraction, multiplication or division. However, elementary algebraic calculators cannot compete with **RPN** machines when more complex operations are required. This is because the special input memory registers of **BPN** calculators form part of a versatile set of problem-solving registers called the operational stack. Figure 1 is a typical example of how the operational stack permits an RPN calculator to solve a complex sum-of-products problem more efficiently than an elementary algebraic machine.

Both methods produce the correct result, but the RPN method requires fewer keystrokes. This is because the result of the first expression (2×6) is automatically stored in the stack when the second expression is entered.



Above is a pictorial representation of an RPN operational stack with four memory registers. The display *always* shows the contents of the x register, but when the **ENTER** key is pressed, the number in the x register is duplicated into the y register. The number remains in the x register but is written over if a new data entry is executed. Figure 2 shows how the first expression in our example problem looks.





Now that the two numbers are stored in the x and y registers, they can be multiplied together (Figure 3).

Notice how the stack *auto-matically* saves results while eliminating superfluous numbers. In Figure 4 you'll see the rest of the problem.

Again, notice how the stack automatically pushes intermediate results upward when a new number is keyed into the calculator. The intermediate result eventually drops back into the y register and in the last operation is added to the contents of the x register to display the answer.

This problem can be solved by an algebraic calcu-



3

12

3

t

z

y 3

х

12

3

+

 $(a \times b) + (c \times d) =$ to $\left(\frac{a \times b}{d} + c\right) d =$ or, $(2 \times 6) + (3 \times 5) = \left(\frac{2 \times 6}{5} + 3 \times 5\right)$

As revised, the problem requires only one more keystroke than the RPN method-but the revision itself is lengthy and time consuming.

To better cope with complex problems like this, the elementary algebraic language can be expanded into what is called the Algebraic Entry System with Hierarchy (AESH). Calculators which have AESH complete multiplication and division before addition and subtraction. This allows you to enter the example problem like this:

5

t

z

y 12

x

15

X

t

z

y | 3

х

12

5

(2 x 6) + (3 x 5) = 27

2	x	6	+	3	x	5
=	27.]		

However, if the example is changed from a sum-ofproducts to a product-ofsums problem, the AESH language provides an incorrect result:

 $(2+6) \times (3+5) = 64$



RPN solves both problems in an identical fashion without error:

[+]

t

z

v

х

t

z

У

x 27



Thus while hierarchy *does* facilitate problem solving, it is obvious that the user must carefully set up a problem or he will get incorrect results. To get rid of this limitation, AESH can be expanded to include a pair of parentheses

keys. These permit a product-of-sums problem like the example to be entered exactly as it is written on paper:

 $(2+6) \times (3+5) = 64$ $(2+6) \times (3+5) = 64$ (3+5) = 64

The calculator language which results from combining AESH with a pair of parentheses keys is called the Algebraic Operating System (AOS). With AOS an algebraic machine has problemsolving capabilities comparable to that of an RPN machine, although AOS still requires somewhat more keystrokes than RPN to solve most problems.

So Which Language Is Best?

All claims of manufacturers and users aside, both algebraic entry and RPN are successful calculator languages. Each is used every day by literally hundreds of thousands of calculator owners.

AOS enthusiasts claim that their calculators permit a problem to be *entered* into the calculator in the same order that it would be written on paper. RPN users counter by noting that their calculators permit a problem to be *solved* the way it would be done on paper. (Remember that both RPN and algebraic calculators solve one-number operations—e.g. sin, log, x^2 —using RPN.)

Algebraic language has a subjective advantage since it is initially more representative of traditional paper and pencil problem solving. In addition, some advanced algebraic machines offer up to *nine* levels of parentheses and keep track of up to 10 pending operations. This certainly enhances the solution of very complex problems. An RPN calculator, however, offers a more flexible approach to problem solving. And the RPN language—like the venerable abacus—displays all intermediate results to assist in error detection. Moreover, RPN offers somewhat improved keystroke efficiency and unmatched approachability, thanks to the ever-present stack.

Since you will no doubt use the advanced calculator you ultimately select for several years or more, the best advice is to spend some time with calculators using both languages so that you can better appreciate how each works. Try some sample problems like those given earlier in this section to get the feel of working with both algebraic entry and RPN. You may find that one will suit vour particular problemsolving needs better than the other.



Functions, Memories, Features– Know What You Need

Whatever the machine's language, a calculator's usefulness is very much determined by such things as its keyboard functions, memory capacity and display features. In this section you'll find information about each of these areas that will help you decide just what you need on an advanced calculator to meet your specific needs.

Keyboard Functions

All advanced calculators have keys for entering the digits 0-9 and executing an assortment of special purpose mathematical functions and operations. They also have a cluster of instruction keys for such purposes as clearing the calculator and controlling both the display and memory.

The various instruction and special-purpose function keys can be classified into these broad categories:

1. General Keys-those which execute instructions and mathematical functions common to both scientific and business calculators.

2. Specialized Keys-those which execute special-purpose scientific, financial or statistical functions.

The accompanying table divides many keys commonly found on advanced calculators into these areas.

Many advanced machines have so many keyboard operations that individual keys are assigned one or more secondary functions. These secon-

Common Advanced Calculator Keyboard Functions

1. GENERAL KEYS	
INSTRUCTIONS	
CE or CLX	Clears entry (previous entry and memory unaffected)
CLR	Clears calculator
ENTER or ENT or 🕈	Enters number into stack*
R↓	Rolls stack to review contents*
=	Completes pending operation ⁺
(and)	Parentheses ⁺
$\chi \ge \gamma$	Exchanges x and y register contents
Last X	Recalls last x entry*
CHS or +/-	Changes sign
EEX	Enters exponent (for scientific notation)
FIX	Fixed notation
SCI	Scientific notation
ENG	Engineering notation (n x 10^3 , 6, 9)
*RPN only +Algebraic only	,
MATHEMATICAL FUNCTIO	NS
+	Addition
_	Subtraction
x	Multiplication
÷	Division

1/x	Computes reciprocal of displayed number
%	Computes x percent of y
x ²	Squares displayed number
√ X	Extracts square root of displayed number
у×	Raises number in y register to power in display
×√y	Extracts xth root of previously entered number
log	Computes common log of number in display
10×	Raises 10 to the power in display
IN	Computes natural log of number in display
е×	Raises e (2.718) to the power in display
x!	Computes factorial $(1 \times 2 \times 3 \times n)$ of displayed number

2. SPECIALIZED KEYS SCIENTIFIC FUNCTIONS

DEG Sets angular functions in degrees mode RAD Sets angular functions in radians mode GRD Sets angular functions in grads mode tan or tan⁻¹ Computes tangent or arc tangent of number in display computes sine or arc sine of number in display sin or sin⁻¹ Computes sine or arc sine of number in display continued on page 10

continued from page 9

cos or	cos-1	Computes cosine or arc cosine of numbe in display
tanh		Computes hyperbolic tangent of number in display
sinh		Computes hyperbolic sine of number of display
cosh		Computes hyperbolic cosine of number in display
Π		Displays pi (3.14159)
	or D.MS	Converts displayed decimal hours (or degrees) to hours/min./sec. format
→ H or	D.MS-1	Converts displayed hours/min./sec. to decimal hours (or degrees)
⇒ R or	P/R-1	Rectangular coordinate conversion
► P or	P/R	Polar coordinate conversion
FINANCI	AL FUNCTI	ONS
PV		Present value
FV		Future value
[i]		Interest rate

PV		
FV		
i		
n		
РМТ		
Δ%	or	%ch

CTIONS
Present value
Future value
Interest rate
Number of periods
Payment for period
Computes % of change from number in y

NPV			Net present value
IRR			Internal rate of return
YTM			Yield to maturity (bond calculations)
INTR			Interest (bond calculations)
BOND			Bond (bond calculations)
SOD			Sum-of-the-years depreciation
DATE	and	DAY	Calendar functions

STATISTICAL FUNCTIONS

Σ +	Summations
Σ -	Negative summation (for deleting data)
S	Standard deviation
x	Mean (arithmetic average)
LR or TL	Linear regression
ŷ	Linear estimate
VAR	Variants
r	Correlation coefficient
N.D.	Normal distribution
POISS	Poisson distribution
GAUSS	Gaussian distribution
BINOM	Binomial distribution

dary functions are identified by colored markings printed on or adjacent to the key and are selected by first pressing a prefix key having the same color. For example, suppose part of the keyboard of an advanced calculator looks like Figure 5.

The log key would be selected by simply pressing log, but the **DEG** key would require this sequence: EE. Advanced calculators which require a prefix key to be pressed before very common operations can

be executed should be avoided if possible.

Although an advanced calculator may have 24 or more keys (as compared to 15 or 16 on a simple calculator), it is important to pay close attention to just what keys are included. Be sure to select a calculator which has operations, instructions and functions you most need. If a machine does not incorporate one or more functions you require, find out how easy it is to duplicate the missing function(s) with a



simple keystroke sequence. For example, duplicating a missing factorial key would be both tedious and time consuming for large numbers. In contrast, you can easily duplicate a missing $\boxed{\mathbf{x}}$ key by using the 1/x and y^{x} keys. Here's how you would extract the cube root of 64 in this manner:

 $3\sqrt{64} = 4$

RPN	AOS
6	6
4	4
+	yx
3	3
1/x	1/x
у×	=
4.	4.

Memory Registers

A memory register is an electronic storage circuit capable of retaining any number which can be keved into the

calculator. All advanced scientific and business calculators have at least one memory, and as you will recall from the discussion of calculator languages, RPN machines include a set of special number-processing memory registers called the operational stack.

You can probably handle most of your problem-solving requirements with an advanced machine having only one memory register. especially if it is complimented by a three- or fourlevel RPN operational stack. However, the computational ability of any advanced machine, particularly programmable models, is enhanced by multiple memory registers.

Even more important than the number of memory registers is the ease with which a number in the display can be arithmetically combined with the contents of the memory. This ability is called register

Memory Operations

Basic store and recall instructions (present on all advanced calculators):

STO	or	MS

Stores displayed number in memory.

- RCL or MR
- The number in the memory is duplicated in the display.

СМ

The memory is erased (electrically cleared to zero).

Calculators with multiple memory registers designate the appropriate memory by following the memory instruction with an address key:

STO	1
RCL	5

Stores displayed number in memory register 1.

The number in memory register 5 is duplicated in the display.

Most advanced calculators are capable of at least some memory register arithmetic:



Displayed number is added to memory.

Displayed number is subtracted from memory.

Displayed number is multiplied by memory contents and the product stored in memory.

M÷

Displayed number is divided into memory contents and quotient stored in memory.

Calculators with multiple memory registers accomplish memory arithmetic with keystroke sequences designating the arithmetic function and the appropriate memory address. For example, [STO] + 3 adds the displayed number to memory register 3.

arithmetic, and the best calculators have at least one fully addressable memory register which allows displaymemory arithmetic. The keystrokes which are fairly typical of conventional and addressable memory operations are shown in the accompanying table.

Since memory operations will involve perhaps 30 percent of the keystrokes you make on an advanced calculator, be sure to evaluate carefully the memory capabilities of the machines you are considering. A single memory register is adequate, particularly if you can perform memory arithmetic on it. But the optimum choice is a bank of six or more fully addressable memory registers.

Incidentally, calculators with multiple memory registers may have special operating restrictions you should know about. For example, some advanced calculators use one or more of their memory registers for such operations as tallying summations or deriving trigonometric functions. This may erase data you have previously stored in the affected registers.

Display Features

The display is the only means a calculator has for communicating with its user. The display announces when the machine is turned on and off, shows data entered and the results of calculations, flashes error signals, and indicates signs and exponents.

Most advanced calculators use a display format similar or identical to the one shown below:



Depending upon the calculator and the display format

you select the number 12,345 can be displayed in each of the following manners:

Fixed Point:

)	
---	--

Scientific Notation:

1.2345000 04

 (1.2345×10^4)

Engineering Notation:

1	2		3	4	5	0	0	0	03
_	_	-	_			_	_	_	

(12.345×10^3)

Each format is correct, but depending on your use, one may be far more convenient than the others.

Fixed Point Display

The fixed point display mode, which is common to most advanced calculators, permits you to select the number of digits to be displayed *after* the decimal point. If a numerical entry or result exceeds the number of digits selected, the calculator automatically rounds the least significant digit shown in the display while continuing to perform all calculations at the machine's maximum accuracy. *Both* features are useful, as you can see in this example.

Pencils cost .027 cents when bought in large lots. How much will a gross of pencils (144) cost, to the nearest cent?

144 x .027 = 3.888

To solve this problem you would fix the number of decimal points at two, then multiply 144 and .027. Although the answer is 3.888, the calculator will automatically round it to give you the convenient answer of \$3.89.

Scientific Notation Display

Virtually serious applications for advanced pocket calculators involve very small or very large numbers. Since a calculator display has a limited number of digits, most advanced models express numbers which exceed the capacity of the display in scientific notation.

Scientific notation is a simple shorthand method of expressing a number as a multiple of a power of 10. For example, 10,000 in scientific notation is 1×10^4 . Numbers smaller than one require a negative exponent: e.g. 1×10^{-4} is the same as 0.0001. In each case, the exponent defines the number of digits which separate the number from the decimal point.

Here's an example of how scientific notation simplifies problem solving:

Light travels at the incredible velocity of approximately 30,000,000,000 centimeters in one second. How much time is required for a ray of light to traverse a space defined by an atom measuring 0.00001 centimeters in diameter?

To get the traverse time you would divide the distance by the velocity. The calculator will give you the answer: $3.3333333 \times 10^{-16}$. Without scientific notation, a 17-digit display would be required just to show the first 3 in fixed notation.

In addition to permitting the processing of numbers far smaller or larger than the digit capacity of its display, a calculator with scientific notation simplifies many types of computations.

Engineering Notation Display

Engineers, astronomers, physicists and others who frequently encounter numbers expressed in increments of three decades (e.g. milli-, mega-, tera-, etc.) will find engineering notation a handy feature. This capability is found on a few of the newer, more advanced scientific calculators and when selected, automatically converts entries and results to a modified form of scientific notation wherein the exponent of 10 is a multiple of three (e.g. 10^3 , 10^9 , 10^{12} , etc.). For example:

The fastest shutter setting on most quality cameras is 1/1,000 second or one *milli*second (1 x 10^{-3} second). Most inexpensive cameras have a single shutter speed of 1/60 second. How many milliseconds is the latter time?

The answer could be displayed as:

Fixed: 0.016666667

Scientific: 1.66666666 -02

Engineering: 16.666666 -03

While all three forms of the answer are correct, the engineering notation version is a very obvious 16.7 milliseconds.



Those Amazing Programmables

Pocket programmable calculators offer the ultimate in personal computational ability. These sophisticated problem solvers are by far the most advanced electronic products available to the consumer today. Despite the name, though, no special programming knowledge is required to use a programmable model. In fact, you can program most problems with the same keystroke sequence you would use to solve identical problems on a preprogrammed calculator.

Programming is especially useful for repetitious problem solving, since once you key the program in you can use the calculator to solve similar problems as many times as you wish. The calculator thus becomes "dedicated" to solving your particular problem.

For example, if you're considering the purchase of a car or house, you can write a program which will let you quickly determine the monthly payments for various combinations of interest rates, payment periods and loan values. Or if you have to solve certain mathematical formulas repeatedly, you can easily convert each formula into a program which your calculator can execute in seconds.

In addition to writing programs yourself, you can use programs prepared by experts in many fields to become a proficient problem solver in disciplines other than your own. In a matter of minutes you can key in programs from such diverse fields as nuclear engineering, ecology, astronavigation, medicine, economics and many more.

You can even convert a programmable calculator into a recreational device which will prove a worthy opponent in games it plays with you and your friends. The recreational aspect of programmable calculators is of major interest to many enthusiasts, particularly since devising clever game programs sharpens programming skills.

When you are not using your programmable calculator to run programs, you can switch its program mode switch to **RUN** and use it like any other advanced calculator.

Types of Programmable Calculators

Programmable calculators can be classified according to their programming power as elementary, intermediate or fully programmable.

1. Elementary Programmables. These machines may have up to 100 steps of program memory and a good selection of preprogrammed functions, but they have few of the program editing and control features which characterize more advanced models.

2. Intermediate Programmables. These calculators have considerable problemsolving aptitude since they incorporate such computerlike features as full editing and conditional tests. Conditional tests permit the calculator to compare an intermediate result with any specified numerical value. If the test is true, the calculator continues normal program execution. If the test is *false*. the calculator skips or jumps one or more steps and then continues normal execution. This powerful programming

tool can be used for such applications as running a section of program any specified number of times or detecting errors and improper operations.

3. Fully Programmable Calculators. These most sophisticated machines resemble pocket-size personal computers more than calculators. They can automatically read programs from small magnetic cards no larger than a stick of chewing gum. This capability means that you can customize a fully programmable calculator for virtually any area of advanced problem solving in the few seconds it takes to run the appropriate card through the built-in. motor-driven reader. It also means you can carry a complete program library in a shirt pocket.

Fully programmable calculators also have an assortment of computer-like operations such as these: • User-definable keyskeys which let you execute an entire program with only one or two keystrokes.

• Subroutines—separate programs which can be called at any time by the main program. After the subroutine has been executed, program control is automatically returned to the main program.

• Indirect addressing—an exceptionally powerful programming tool which provides extensive data manipulation capability and actually allows a program to modify itself.

• Flags-signals or status indicators which can be set by the calculator or its user. When a flag is encountered during program execution, the calculator continues to the next step if the flag is set and skips one or more steps if the flag is not set.

• Counters-special registers which can be incremented or decremented at onedigit intervals to cause a section of program to be cycled any specified number of times.

What To Consider When Choosing a Programmable

Purchasing a programmable calculator which will handle your problem-solving requirements (and probably much more) is more difficult than selecting a preprogrammed model. While there are fewer machines from which to choose, there are a great many different features. Here are some important facts to help you make an intelligent, knowledgeable purchase decision:

Editing Features. Programmable calculators are designed to save time, and the better machines incorporate a special set of instruction keys specifically designed for this purpose. These keys permit you to edit your way through a program one step at a time to delete errors and to correct mistakes.

Intermediate and fully programmable calculators

also incorporate several display features which greatly assist editing. As the program is keyed (or cycled back for review), the step number appears at the left side of the



display and the selected key function is encoded as a twodigit **keycode** on the right side.

Keycodes are a clever way of assigning each key on the calculator a two-digit number. The 10 digits are encoded as 00, 01, 02, etc. All other keys are encoded according to their position on the keyboard. The first digit specifies the row of keys and the second digit, the number of the key in that row. For example, the keycode for sine on the keyboard shown at the left is 12. Which key does the keycode 64 designate?

Program Capacity. Be wary of manufacturers' claims when evaluating a calculator's program capacity. The total number of available program steps is certainly important, but the efficiency with which those steps can be used is even more significant.

A calculator's language plays a role in determining

program capacity. For instance, RPN make somewhat more efficient use of program memory space since RPN programs are generally shorter than those of AOS calculators.

Even more important is whether or not the calculator has fully merged keycodes. All intermediate and fully programmable machines use one or more prefix keys to designate the secondary functions assigned to various keys. The resultant two-step sequence is usually merged into a single step of program memory in what is known as merged prefix.

Other multiple keystroke operations may not be merged on some machines. For example, <u>STO + 1</u> requires three steps of program memory on a nonmerged machine:

1	STO	
2	+	
3	1	

A fully merged machine squeezes all three keystrokes into one step of program memory:



Availability of Well-Documented Programs. The usefulness of a programmable calculator is very much enhanced by the existence of a wide range of programs in various disciplines. Although you will eventually accumulate a library of your own programs, you can save considerable time by using programs prepared by others. A few manufacturers of the most sophisticated programmable calculators provide users with well-documented, prepared program libraries for a nominal fee. Programs can also be obtained from calculator clubs, universities, various publications and friends who own programmable calculators.



How To Compare Calculator Construction

However good the internal operation of a calculator, the quality of its external construction is an important consideration when making a purchase. You'll find that highly advanced machines are often housed in fragile boxes of squared-off, angular plastic with row after row of illegible, squishy keys.

Only a few manufactuers invest the time, energy and money in the comprehensive "human engineering" necessary to produce a machine that has a good "feel" and is sturdy and easy to use. Such a machine usually costs somewhat more. However, a human-engineered calculator with a powerful computational ability is a delight to operate.

To help you determine if the benefits of human engineering are worth the additional cost, here's a point-bypoint analysis of five important construction elements.

1. The Keyboard. There are more types of keyboards and keyboard layouts than there are manufacturers of calculators. Fortunately, however, keyboards are easy to evaluate. Here's a list of tips which will help you. For best results, go over the list point by point while actually examining a calculator.

• Do the keys feel squishy or do they firmly click into action when pressed? Nonclick keyboards are easier to make and, consequently, cheaper. Click action keys, however, provide a tactile signal that a number or function has been entered—which means you don't have to glance at the display.

• Try pressing a digit key and then wiggling it about in its depressed position. This may cause unintentional multiple digit entries on poorer quality keyboards, particularly the non-click action kind.

• Are the keys clearly labeled? Try shading the calculator to see if you can easily read the labels in subdued light. Ask if the keys themselves are double injection molded. This neat construction feature costs more, but the key markings never wear off since they are molded through the entire body of the key.

• Finally, is the keyboard layout well organized and visually appealing? Smaller keys placed some distance apart are easier to press than larger, closely spaced keys-particularly if you have large fingers. A careful use of color for markings and keys will help you find your way through the maze of functions that advanced calculators feature.

2. The Display. Advanced calculators use several types of displays. Liquid crystal displays are the easiest on batteries, but they are generally more difficult to read than displays which produce their own light. The two most common displays are electrofluorescent (EF) and lightemitting diode (LED) types. EF displays produce a pleasant blue-green glow, while most LED displays emit a bright red light. Both are easier to read than the liquid crystal type, but the LED type has a much longer operating life (at least 50 years of continuous operation!).

Most advanced calculators use LED displays. However, each manufacturer incorporates subtle but significant design variations. For example, a display can be made brighter by increasing the current through it-but this decreases battery life. A display can also be made brighter by using small plastic bubble lenses to concentrate the light in the direction of the user. But this creates a very narrow field of view which severely restricts the location of the calculator while it is in operation.

While the main purpose of a calculator display is to show numerical entries and results, it may also provide several indicators and cues. Most signify errors and such illegal operations as $5 \div 0$ or sin⁻¹ 10 by flashing the display. Some newer machines actually spell out:

Error

When an operation results in a number larger than the calculator's capacity, the calculator indicates an "overflow" by a flashing display, an indicator light, or either a flashing or steady

9.9999999 99

Not all calculators indicate overflows which result from

memory register arithmetic. Several which do cause the display to spell out

OF

Some calculator displays warn the user when the charge on the batteries is nearly exhausted. One common low voltage cue is a special warning light. Another is the simultaneous activation of all the decimal points in the display. As anyone who has lost battery power without warning in the midst of a lengthy calculation can testify, a low battery voltage cue is a valuable feature.

Since the features of various displays are so diverse, you should actually view several calculators at your retail dealer to compare displays and see which you prefer.

3. Moisture and Dust Barriers. Liquids and keyboards don't get along well, so quality calculators incorporate a polyethylene or mylar moisture barrier under the keyboard to guard against that occasional coffee spill. This seal also restricts the entry of dust which might cause faulty operation.

Be sure to ask if the calculator you're considering includes a moisture barrier. And then look the machine over for cracks and other openings which invite the entry of dust and other potential contaminants.

Incidentally, advanced calculators include various degrees of sealed battery compartments. Some are entirely or partially sealed. but others expose a wide expanse of circuit board when opened. A sealed battery compartment offers the most protection and is the best choice. An open compartment, however, isn't a fatal flaw if you are careful to keep foreign matter out of the compartment when removing the batteries.

4. The Package. Calculator packaging methods, styles and approaches are by far the most versatile aspects of calculators. Fortunately, packaging quality is easy for the layman to evaluate. Simply hold the calculator to get its "feel" and ask yourself if it would withstand a drop to the floor. Does the case seem thin and flimsy? Does it twist or flex with a little pressure? If so, chances are it won't last long in the active world of the typical calculator user.

Next, how comfortable does the calculator package feel in your hand? Is it comfortably contoured or tapered? Or is it uncomfortably sharp and angular? Finally, if portability is an essential requirement, is the calculator small enough for your needs? While the numerous keys of advanced calculators make them somewhat larger than the basic machines, many can still be slipped into a shirt or coat pocket.

5. The Power Supply. Most advanced calculators are powered by disposable batteries or rechargeable power packs. Although more expensive initially, the rechargeable type provides cheaper operation. Whatever power supply option you prefer, make sure the manufacturer supplies an appropriate line-operated charger or auxiliary power supply.

An Additional Consideration: Manufacturer Support

An examination of the physical construction of a calculator will tell you a great deal about the quality of the product. In addition, you should check out these three areas:

1. Warranty. It's safe to conclude that in the advanced calculator market the length of the warranty is directly proportional to the quality of the machine. Thirty-, 60- and 90-day warranties generally characterize machines of mediocre quality, while full one-year warranties are typical of better constructed calculators.

2. Service. A warranty is only as good as the service when problems provided occur, particularly since the repair of advanced calculators is not a trivial matter. You can check the company's sales literature and promotional brochures for service information, but your best bet is to ask around. Question your friends and calculator dealers to determine how long it takes to get particular brands repaired and to find out which manufacturers best live up to the services promised in their warranties.

3. Applications Information. When looking at various machines, always ask the salesperson to show you samples of each manufacturer's applications information. Several manufacturers of quality advanced calculators publish excellent applications information.

The Choice Is Yours

The actual selection of a calculator is now up to you. With the information in this booklet serving as a foundation, visit your retail dealer and ask for a hands-on demonstration of a variety of high-powered problem solvers. Evaluate the machines in accordance with your needs, your budget, the overall quality of the various calculators, and the service and support provided by the manufacturers.

Take your time. Selecting an advanced calculator is not a trivial matter, so be sure you thoroughly understand the various options and tradeoffs *before* making your purchase.

Whatever advanced calculator you select, we hope you will enjoy new heights of computational efficiency, ability and competence.

Introducing Hewlett-Packard.

When William R. Hewlett and David Packard founded Hewlett-Packard in 1939, they offered only one product—an audio oscillator. But it was superior to all others available at the time. And their policy—of introducing only products that fill a need and provide lasting value—has continued for more than three decades.

Today, Hewlett-Packard offers more than 3,000 different products, ranging from microscopic components to complete computer systems. The company is one of the world's leading designers and manufacturers of electronic, medical, analytical and computing instruments and systems. In the data processing field, Hewlett-Packard offers the most extensive line of computing alternatives for science and engineering. Beginning with mini-computers for science and engineering, HP went on to design and manufacture electronic, programmable desktop calculators; computer systems for business, industry and education; a small-scale computer system with multi-programming and multi-lingual capabilities, and an extensive selection of peripherals (disc memories, plotters, etc.) and software.

Then HP utilized this knowledge and experience to introduce the world's first pocket-sized scientific calculator the one which set the standard for all other brands and models. As you will see on these pages, Hewlett-Packard now offers The First Family of pre-programmed and programmable pocket calculators designed for professional use. Their owners include Nobel laureates, astronauts, business people, doctors, scientists, students, educators and engineers in every field. More than one million-strong worldwide. And perhaps, you!

RPN Logic

The most sensible logic system a pocket calculator can have!



One of the most important considerations in purchasing a calculator is evaluating its logic system. HP thoroughly evaluated the strengths and weaknesses of the various logic systems which a person might use to communicate with an electronic calculator.

Algebraic logic, for example, was in more common use and worked well with simple calculations, but when working complex problems it was often necessary to restructure the equation.

So, after much testing and evaluation, Hewlett-Packard selected a parenthesis-free but unambiguous logic system derived from the one developed by a mathematician named Jan Lukasiewicz. It's known as "RPN" logic.

Harvard Professor John Ball, writing about RPN in the January 18, 1975 issue of *Electronic Design* stated: "In an objective evaluation, based on algorithms for all basic arithmetic operations with four variables, RPN gets the best score." (Of all logic systems tested.)

He continued: "Though RPN uses fewer keystrokes on the average, which system to use is a subjective decision. For the author, again RPN won. He made fewer mistakes and selected it for his personal use." Only RPN—in combination with a 4-register memory stack—gives you these powerful advantages:

- 1. All functions operate the same straight-forward way. When you press the key, the function executes.
- 2. You can approach all problems the same way—stepby-step starting with the innermost set of parentheses. Yet, you don't have to worry about a parenthesis key or the effects of a complicated "algebraic hierarchy."
- 3. You don't have to think your problem through beforehand to determine the best method-of-attack or where to insert an implied operation.
- 4. You always see all intermediate answers—as they are calculated—so that you can check the progress of your calculation as you go, or jot down an important number for future reference.
- 5. You can review or rearrange all data stored in the calculator at any time by pressing a few keys. There is no "hidden" data.
- 6. You can easily recover from errors. Since all operations are performed sequentially, it is a simple matter to reverse an erroneous step.
- 7. You don't have to write down and re-enter intermediate answers, a real time-saver when working with numbers of eight or nine digits each.
- 8. You can use your calculator confidently, knowing that it will solve each problem in the same straightforward manner.

Hewlett-Packard presents the first family of advanced scientific and business calculators.

Hewlett-Packard built the world's *first* advanced pocket calculator back in 1972. And led the way ever since. Today, Hewlett-Packard offers a combination of technology, features, human engineering, back-up support and lasting value not available anywhere else.

Hewlett-Packard calculators are recognized as The First Family by more than one million owners worldwide. Including Nobel Prize winners, USA-USSR astronauts, explorers, educators, scientists, businessmen, and students. Here's why:

First family design. Hewlett-Packard was first to translate state-of-the-art technology into advanced pocket calculators. The result: Professional products with innovative features that solve problems more easily and — more importantly —*extend* the user's capabilities beyond previous limitations. By design.

First.family performance. Hewlett-Packard *means* performance. The kind of performance that includes RPN logic with four-memory stack. A full range of advanced features. Powerful full programmability on some calculators. On others,

Continuous Memory CMOS technology. And more. In a word: Performance. In a calculator: Hewlett-Packard.

First family reliability. When you buy a Hewlett-Packard calculator you get one year's protection on parts *and* labor. And a two working-day turn-around on most repairs. When Hewlett-Packard builds it, Hewlett-Packard backs it.

First family support. Every Hewlett-Packard calculator comes with its own comprehensive Owner's Handbook. In addition, a complete selection of optional accessories increase the versatility of your calculator: application books, battery packs, programming worksheets, rechargers, cases and desk-top security cases. Hewlett-Packard offers more because Hewlett-Packard's got more to offer.

How to get additional information. If you would like additional information about any Hewlett-Packard calculator on the following pages—write: Hewlett-Packard, Dept. 225A, 19310 Pruneridge Avenue, Cupertino, CA 95014. After Nov. 1, 1976 write: Hewlett-Packard, Dept. 225A, 1000 N.E. Circle Boulevard, Corvallis, Oregon 97330.

The first family of preprogrammed calculators. (please see opposite page)

HP-21 Scientific. The HP-21 makes short work of the technical calculations even so-called "non-technical" courses require today. If you need a calculator that does more than simple arithmetic - this is it.

- 32 built-in functions and operations.
- Performs all standard log and trig functions (in radians *or* degrees).
- Performs rectangular/polar conversion, register arithmetic and more.
- Addressable memory.
- Two selectable display modes: Fixed point and scientific.

HP-27 Scientific/Plus. The HP-27 is for the science or engineering student whose course work extends into business administration. The reason: It features every pre-programmed scientific function we've ever offered, plus comprehensive stat and financial functions. That's why we've dubbed it our Scientific/Plus.

- 28 pre-programmed exponential, log and trig functions, 15 statistical functions, 10 financial functions – 53 in all.
- 10 addressable memories 20 memories in all.
- 6 selective clearing options give you flexible use of memories.
- Fixed decimal, scientific or engineering display formats.

HP-22 Business Management. The

HP-22 easily handles the kinds of calculations you face in business courses today, in management tomorrow. Breeze through business math calculations. Build existing statistical data into reliable forecasts. If you're going into business administration, this is the calculator for you.

- Combines financial, mathematical and statistical capabilities.
- Performs complex time-value-of-money computations including interest rates.
- Performs rates of return and discounted cash flows for investment analysis.
- Performs extended percent calculations, accumulated interest, amortization, etc.
- Ten addressable memories.
- Full decimal display control.

The first family of programmable calculators. (please see back cover)

HP-25C Scientific Programmable with Continuous Memory. The HP-25C is our keystroke programmable. It can solve automatically the repetitive problems every science and engineering student faces. What's more, its Continuous Memory capability lets you retain programs and data even when it's turned off.

- Continuous memory capability.
- 72 built-in functions and operations.
- Keystroke programmability.
- Branching, conditional test and full editing capability.
- Eight addressable memories.
- We also offer the HP-25, without the Continuous Memory feature.

HP-67 Powerful Fully Programmable.

The HP-67 is the most powerful fully programmable scientific pocket-sized calculator Hewlett-Packard's ever built. And it's easy to use, too. Improper card loading is virtually impossible with our "smart" card reader. Plus, it's exceptionally easy to edit. If you need a powerful pocket-sized fully programmable, this is it.

- Hewlett-Packard's most powerful pocket-sized calculator.
- Handles programs of up to 224 steps.
- All prefix functions are merged.
- Directly records contents of all 26 data storage registers onto magnetic cards.
- 3 types of addressing—Label, Relative and Indirect.

- Easy to use —"smart" card reader automatically records program status of flags, display, angular modes.
- Standard Application Pac with 15 programs of general appeal included free. Optional Pacs in Engineering, Finance, etc., available at modest cost.
- We also offer the brief case portable HP-97, featuring all the power of the HP-67 plus a built-in thermal printer.



Sales and service from 172 offices in 65 countries. Dept. 225A, 19310 Pruneridge Avenue, Cupertino, CA. 95014.

616/28



HP-25C Scientific Programmable with Continuous Memory.

455

FIX

Nº23

GIO

RA

ENTER

*27

×

3500

510

9

EEX RAD

109

8

RCL

De

CHS

Et

STK

5

9

6

3

RIS

LE HEWLETT PACKARD 25C (Also available without Continuous Memory-the HP-25.)

234567890-6

OFF

115

x2

n

CL REG

છ

PAUSE

0 LSTX */* */°CH

5

CL PROM

9

6 ABS

INT FRAC . PACKARD

3 REG

+ H.MS

RIS

STY

157

PZS

XEY

×70 ×7Y

6P

RA

FIX SCI

9

WIDATA

DSZ (II)

XEY

XES

,0

MERGE

X=Y

.0

-0

HEWLETT HP-67 The Powerful Fully Programmable.

5952-6053D Printed in U.S.A. 8/76