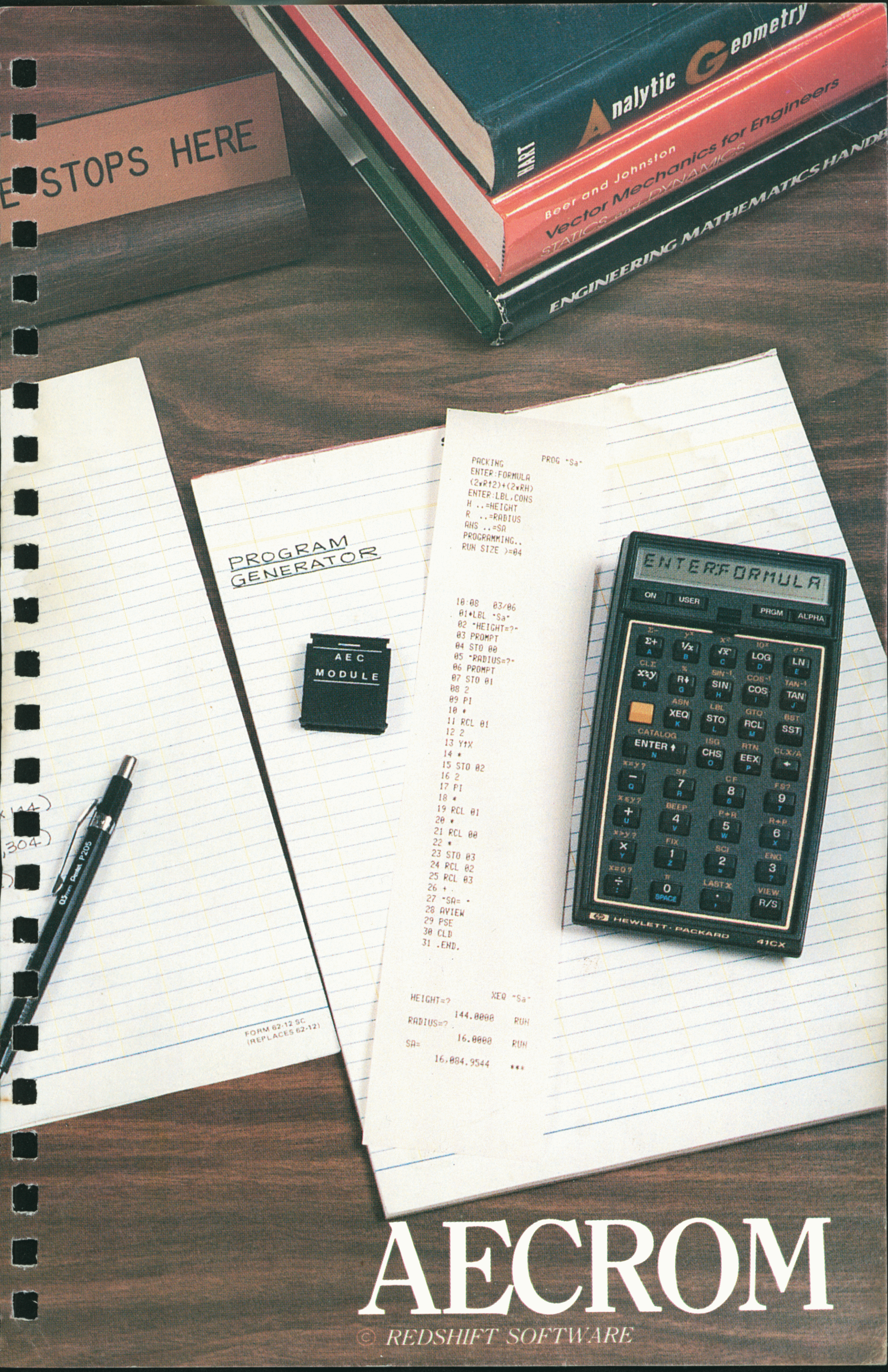

STOPS HERE
Analytic Geometry
HART
Beer and Johnston
Vector Mechanics for Engineers
STATICS and DYNAMICS
ENGINEERING MATHEMATICS HANDB
PROGRAM GENERATOR
AEC MODULE
ENTERFORMULA
HEWLETT·PACKARD
41CX

AECROM

THE AECROM USER'S MANUAL

The Architecture, Engineering, and
Construction

ROM Module for the HP-41

Redshift Software

7614 Lakecliff Way

Parker, Colorado 80314

Acknowledgements

The AECROM was conceived and designed by Wilson W. Holes and made possible through the joint efforts of the ROM project team: Wilson W. Holes, John M. Test, Dan D. DiVirgilio and Nelson F. Crowle. Special thanks to Nelson, whose dedication and superior programming skills contributed greatly to the quality of this product.

About the Author

This manual was designed and written by Ted Wadman of Terra Pacific Writing Corp. Ted began writing about the HP-41 in 1980 as the technical editor of Hewlett-Packard's HP-41 customer newsletter *HP Key Notes.* Upon the discontinuation of that newsletter in 1982, Ted participated in the creation of the book *An Easy Course In Programming The HP-41.* He has since co-authored several books on Hewlett-Packard calculators and related products, all published by Grapevine Publications, Inc. in Corvallis, Oregon.

In 1986, Ted started Terra Pacific Writing Corp, specializing in writing and producing easy-to-use manuals on all technical subjects or products.

CONGRATULATIONS!

By choosing to own the AECROM Module for the HP-41, you have chosen to make your calculating life easier. The powerful functions and programs contained within this module have been designed specifically for you. They are both useful and easy to use, and they endow your HP-41 (that is, any HP-41C, HP-41CV, or HP-41CX) with incredible calculating (and self-programming) abilities.

The three most broad-reaching features of the AECROM are the units of length modes, the self-programming feature, and the curve fitter. The units of length modes make it easier than ever to work with different sets of units of length (feet, inches, and sixteenths; metrics; decimal inches; and decimal feet). The self-programming feature almost magically turns your algebraic formulas into HP-41 programs (you don't even enter PRGM mode). And the curve fitter helps you fit your experimental (X,Y) data pairs to any of sixteen curves.

These three features, along with the rest of the AECROM functions, make it an incredibly useful addition to your HP-41. But you'll see all this in the upcoming pages of this manual. So take a moment and scan over the table of contents, then begin reading at "Getting Started."

TABLE OF CONTENTS

Getting Started

This manual contains everything you need to learn all about using your AECROM quickly and easily. The explanation in this manual assumes that you know about the stack registers in your HP-41 (X, Y, Z, and T), that you know how to do arithmetic on your HP-41, and it sometimes assumes that you know how to execute functions using the [XEQ] [ALPHA] function [ALPHA] method.

If you've never touched the [ENTER] or [XEQ] keys on your HP-41, or if you just get the butterflies whenever you turn it on, other books are available to help you get over your anxieties (your HP dealer can refer you to an appropriate text).

WHAT'S IN THE BOX?

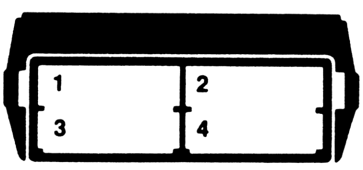
Your AECROM module comes in a box with the following:

1. This Manual.
2. The AECROM module
3. An AECROM brochure and order form to give to a friend or co-worker.

INSTALLING THE AECROM MODULE

Your HP-41 must be turned off when you install the AECROM module. Make sure your calculator is off, then plug the module into one of the four ports in the top. The module will plug in easily and it can plug in only one way.

If you have the HP-41C SURVEYING PAC (41-15005), install the AECROM in a port that has a smaller number than the port that's holding the surveying ROM. The HP-41 port numbers are shown in the following diagram (and on the back of the calculator):



Also, if you have the ZENROM or the CCD ROM, the AECROM is not compatible with either of these ROM's (just as they aren't compatible with each other), so only one of these three ROM's can be installed at a time.

Warning: Static electricity can wreak havoc to (ruin) any integrated circuit. Static discharges from your body that you don't even notice can lock-up or damage this product or your calculator. The best way to avoid any chance of static electricity damage is to never touch the metal parts of the ROM or of your calculator.

TWENTY-SEVEN AMAZING NEW FUNCTIONS

When you plug the AECROM module into your HP-41, you are adding twenty-seven functions (including four programs) to your calculator's already extensive function list. You can view these new functions by executing CATALOG 2.

If you have an HP-41C or HP-41CV, press [ ] [CATALOG] 2 (we use [ ] to represent the gold "shift" key). Your calculator will display the titles and functions of every ROM module that you have plugged in. It will display the title AECROM–1A, then it will display each of the twenty-seven AECROM functions (listed below).

With any HP-41, you can always stop a CAT listing using the [R/S] key. Plus, you can move around in the list by using the [SST] and [BST] keys. You can clear the listing from your display by using [←], or you can restart the listing by pressing [R/S].

If you have an HP-41CX, when you press [ ] CAT 2, you will see only ROM titles. To see the functions in the AECROM, press [ ] [CAT] 2 [R/S] then use [SST] (single step) or [BST] to get "AECROM–1A" in the display and press [ENTER]. The calculator will list the functions in the AECROM module plus any functions in ROM titles that appear below "AECROM–1A" in the CAT 2 list.

Here is the listing of the twenty-seven functions in the AECROM that you see when you execute CAT 2.

>DF	PLC
>DI	PRAD
>F	PRD
>M	PROG
ACD	*CONV
ACOSH	^{T}SARR
ASINH	SINH
ATANH	TANH
CRVF	^{T}TRIA
^{T}CIRC	/CONV
CLBUF	VIEWX
COSH	WAIT
DMS	^{T}CURVE
LPS	

SIX GROUPS OF FUNCTIONS...SIX CHAPTERS

The twenty-seven amazing functions in the AECROM can be divided into six groups. These six groups follow:

1. Units Of Length Modes

>DF	Decimal Foot Mode
>DI	Decimal Inch Mode
>F	Fractional Mode
>M	Decimal Meter Mode
*CONV	Multiplies by the conversion factor of the current mode.
/CONV	Divides by the conversion factor of the current mode.

2. <u>A Program Generator</u>

PROG	Converts your algebraic equations to HP-41 programs.

3. <u>A Curve Fitter</u>

^{T}CURVE	Fits (X,Y) data points to up to 16 curves.
CRVF	A Machine Language curve fitting function you can use in your own programs.

4. <u>Geometric Solvers</u>

^{T}SARR	Slopes, Angles, Rise, and Run Solver
^{T}TRIA	Triangle Solver
^{T}CIRC	Circle Solver

5. Hyperbolic Functions

COSH	Hyperbolic COS
SINH	Hyperbolic SIN
TANH	Hyperbolic TAN
ACOSH	Inverse Hyperbolic COS
ASINH	Inverse Hyperbolic SIN
ATANH	Inverse Hyperbolic TAN

6. Utility Functions

ACD	Accumulates Display in Printer Buffer.
CLBUF	Clears Printer Buffer (only if something is present in the buffer).
VIEWX	Converts the number in the X-register to the current units mode and loads it into the display.
PRAD	Prints the ALPHA-register (left-justified) and the contents of the display (right-justified).
PRD	Prints the display.
PLC	Print a line (24 characters long) of the first character in the ALPHA-register.

WAIT	Pauses program execution (about 1/2 second) without affecting the display contents.
DMS	Degrees, Minutes, and Seconds (works in the display only).
LPS	Long Precision Seconds. Displays the full value of seconds (for use with the above function).

Although you will get the most out of your AECROM if you read every chapter in this manual, each chapter is independent of the others (unless otherwise indicated in the chapter). Each of the following chapters describes one of the above groups of functions and can be read in any order that you like.

And by the way, in performing its powerful functions, the AECROM makes extensive use of the ALPHA register. So, if you switch to ALPHA mode while you're using these functions, you may see some non-standard (weird) characters. These characters are the same characters that you can put in the ALPHA register using the extended function XTOA. Don't let them alarm you.

Chapter 1. Units Of Length Modes

Six of the AECROM functions are designed to make your calculations with different units of length much easier. These functions are:

>DF	Decimal Foot Mode
>DI	Decimal Inch Mode
>F	Fractional Mode
>M	Decimal Meter Mode
*CONV	Multiplies by the conversion factor of the current mode.
/CONV	Divides by the conversion factor of the current mode.

A GENERAL DESCRIPTION

All six of these functions are programmable. The first four mode functions (>DF, >DI, >F, and >M) allow you to work easily with four different formats for units of length, converting back and forth between different sets of units as you please.

The other two functions (*CONV and /CONV) are provided for multiplying and dividing by integers when you are in Decimal Inch Mode or Decimal Meter Mode.

DECIMAL FOOT MODE

Decimal Foot Mode is just the normal operating mode of your HP-41. Fractions of feet are displayed as decimal fractions (tenths, hundredths, thousandths, etc.) like any fraction of a number. The digits to the left of the radix (decimal point) in your display represent whole feet, and digits to the right of the radix represent fractions of feet.

CHANGING UNITS MODES

You can execute any of the units functions (>DF, >DI, >F, or >M) to tell the calculator you want to work with a different set of units, or you can use the unique [ON] key toggle feature that is provided for changing units modes:

[ON] KEY TOGGLE FEATURE

With the AECROM installed and your HP-41 turned on, press and hold down the [ON] key. The four units modes will begin flashing in the display. Release the [ON] key when the desired mode is in the display, and your calculator is set to that mode.

USING THE UNITS MODES

Some examples of using each of the units modes follow. In these examples, the [XEQ] [ALPHA]... process is used to change units modes. If you wish, practice changing modes by using the [ON] key toggle feature described above.

DECIMAL INCH MODE

Example: Convert the following four "lengths in feet" to "lengths in inches."

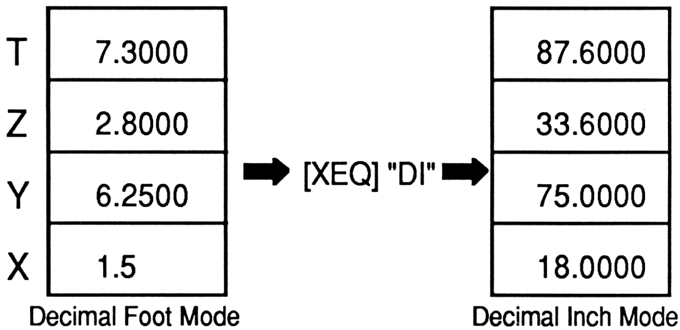
7.3 '
2.8 '
6.25'
1.5'

Solution: Press [XEQ] [ALPHA] >DF [ALPHA] to put your calculator into Decimal Foot mode. (You can key in the ">" character by pressing [ ] [J] in ALPHA mode, so the keystrokes for >DF are [ ] [J] [D] [F]). Again, you can use the [ON] key toggle feature to switch to Decimal Foot mode.

Once you're in Decimal Foot mode, press 7.3 [ENTER] 2.8 [ENTER] 6.25 [ENTER] 1.5 to load the stack registers with the Decimal Foot inputs. Finally, press [XEQ] [ALPHA] >DI [ALPHA] to go into Decimal Inch mode (or use [ON] if you prefer).

The display will show you 18.0000 (with the display set to FIX 4). When you executed >DI to switch to Decimal Inch Mode, the calculator converted that 1.5 feet in the X-register to 18 inches. In fact, all four numbers in the stack will be displayed in inches. Press [R↓] three times to prove this to yourself. The other three values are 75.0000, 33.6000, and 87.6000. All the values in the stack have been converted to inches and decimal fractions of inches. Now press [R↓] to get that 18.0000 back into the display.

The Stack Registers
(as displayed in the two modes)



FRACTIONAL MODE

Example: Add 27.2 inches to 14.6 inches. Then add that result to the 18 inches in the stack, and finally, convert the result to feet, inches, and sixteenths.

Solution: 27.2 [ENTER] 14.6 [+] [+] [XEQ] [ALPHA] >F [ALPHA] (again, the ">" character is on the [ ] [J] key).

Now your display looks like this: 4' 11–13/16". The result in inches was 59.8 inches.

When you switched to Fractional Mode by executing >F, the calculator converted that result to it's equivalent fractional representation. In Fractional Mode the calculator rounds the displayed number to the nearest 16th.

DECIMAL METER MODE

Example: Subtract 2' 4–7/16" from the number in the X-register. Convert the answer into meters.

Solution: 2.04716 [–] [XEQ] [ALPHA] >M [ALPHA]

After you press the [–] key, the answer in your display is 2' 7–3/8". Then, when you switch to Decimal Meter Mode by executing >M, that answer is displayed as its metric equivalent (.7966).

Now press [XEQ] [ALPHA] >DF [ALPHA] to put your calculator into its normal operating mode (Decimal Foot Mode).

UNIT MODE KEY ASSIGNMENTS

You can assign any of these unit mode functions to keys on your calculator as you would with any function. If you find yourself switching back and forth between modes, you may find it convenient to assign each of these mode functions to a key (or a shifted key). But, if you use just one mode, you may want to set your HP-41 to that mode and leave it.

(As an example of assigning a function to a key, the keystrokes for assigning >F to the [ ] [SF] key are: [ ] [ASN] [ALPHA] >F [ALPHA] [ ] [SF].)

UNITS MODES AND CONTINUOUS MEMORY

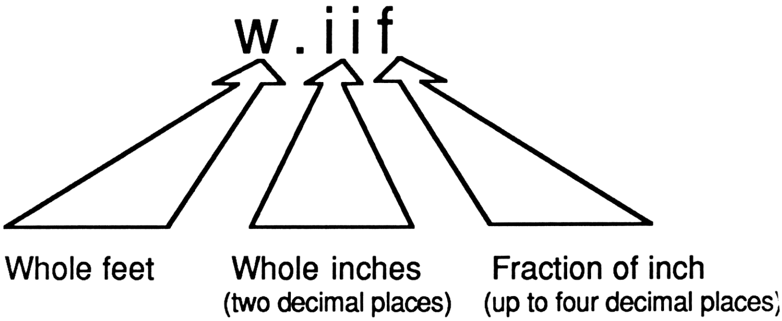
Once your HP-41 is set to a certain units mode, the continuous memory of the HP-41 will retain that setting when the calculator is off. If you remove the AECROM, the calculator will revert to its normal operating mode until you reinstall the AECROM, at which point the most recent units mode setting will be remembered (provided the HP-41's continuous memory hasn't been interrupted).

DETAILS OF FRACTIONAL MODE

Of the four modes, only the Fractional Mode requires you to know anything special about inputting numbers. The other three modes are decimal modes, so you simply key in the numbers as you always have. The first place to the right of the radix is for tenths, the second place is for hundredths, etc.

But in Fractional Mode, these are the rules:

1. Numbers are input in the format w. iif, where "w" can be any integer that represents whole feet (to the left of decimal point), "ii" can be only a two digit integer that represents inches, and "f" is the fraction of an inch.



2. Any fraction that is an integer multiple of 1/16 is an acceptable value for "f." If you input two digits for "f," the first digit will be taken to mean the numerator and the second digit the denominator of a fraction (for example, 12 will be taken to mean 1/2", 38 will be taken as 3/8", and 5/4 will be taken as 1-1/4"). If you input three or four digits for "f," the last two digits should be 16 (for example, 516 is 5/16 and 1516 is taken as 15/16).

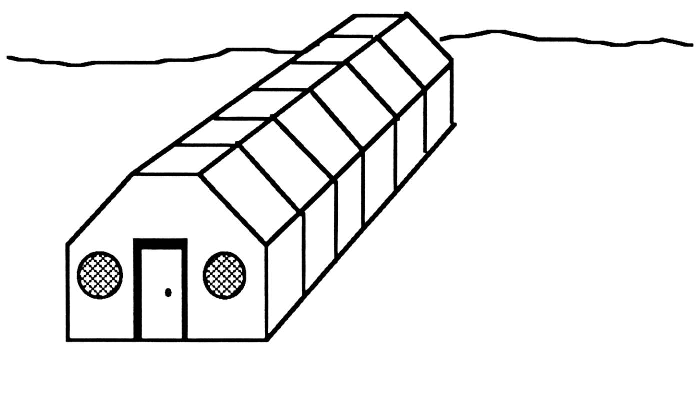
3. Any number of digits (limited by the HP-41, of course) can be input for the whole feet portion ("w"). Exactly two digits must be input for the inches portion ("ii"), and up to four digits can be input for the "f" portion. ("If more than four digits are input for "f," they will be ignored.)

Here are a couple more examples to test your knowledge of the above three rules for inputting numbers in Fractional Mode. Remember, to set your HP-41 to Fractional Mode, execute the function ">F."

Example: Add 5' 0–3/16" to 7' 7–7/8".

Solution: Press [XEQ] [ALPHA] >F [ALPHA] remembering that the ">" character can be keyed in by pressing [ ] [TAN]. Then press 5.00316 [ENTER] 7.0778 [+]. The answer is 12' 8–1/16".

Example: You're building a greenhouse and part of the materials you need to buy include forty-two 2' 4–7/16" lengths of cable. To cut costs, you decide to buy one continuous length of cable and cut it into the shorter lengths yourself. How long does this cable need to be?



Solution: Press 42 [ENTER] 2.04716 [X]. The answer is 99' 6–3/8".

Now store that result in register 00 (press [STO] 00).

Note: *If you wish to multiply using Decimal Inch* *or Metric Mode, see examples* *on page 27 first.* *If you want to multiply by anything other than an integer in Fractional Mode, you must first switch to Decimal Foot Mode.*

FRACTIONAL MODE OVERFLOW

Occasionally, a number in fractional mode will be too long to fit in the display. When this occurs, a colon (:) appears at the right side of the display to indicate that some of the digits in the whole feet portion of the number are not visible.

Example: In Fractional Mode, key in the number 959725.0458 (959725 feet, four and five-eigths inches) and press [ENTER]. The display will show:

59725' 4–5/8":

The colon indicates that you aren't seeing some of the leading digits (the first 9). You can view the decimal foot representation of the number (to see the missing digits) by pressing the [ALPHA] key once, then pressing it again and holding it down.

DETAILS OF THE FOUR MODES

It's interesting to notice that when your calculator is set to any one mode (Decimal Feet, Decimal Inch, Fractional, or Decimal Meter), the calculator acts like that mode is the only one it ever works in. You just key in numbers, keeping the appropriate units in mind, then you can add, subtract, store, recall, and perform any of a majority of HP-41 functions without even thinking about the mode you're in.

Then, when you decide to work with a different set of units, you just switch to a different mode, and every number in your calculator appears to be converted to that new set of units.

How do you think this is done? If you know about programming the HP-41, you know that it would take a while for a program to convert every number in every register to a new set of units (multiplying each number by a conversion factor), yet when you execute one of the AECROM functions to switch modes, the conversion is almost instantaneous.

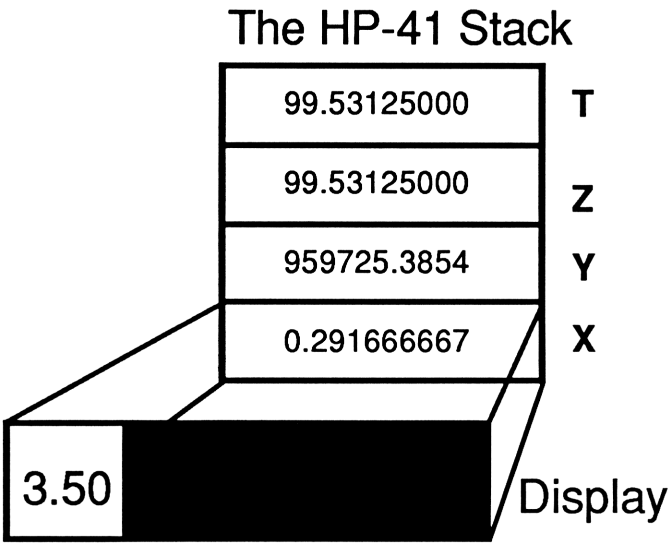
Well, the reason this conversion takes place so quickly is that it happens only in the display. No registers are affected. Every number is stored in its Decimal Foot form.

To prove this to yourself (if you need proof), press [ ] [VIEW] 00. In the example on page 22, you stored the number 99' 6–3/8" in register 00, but when you view that register, you see 99.53125001 (FIX 9). The VIEW function fills the display with what's actually in that register.

As another example, when you are in Decimal Inch mode, and you press 3.5 [ENTER], the number 0.291666667 is pushed onto the stack. The display will show you 3.50, but the HP-41 is storing the number as 0.29.... If you press [ ] [VIEW] X, you will see the number that is actually stored.

THE DISPLAY VERSUS THE X-REGISTER

If you're confused about this difference between the display on your HP-41 and the X-register, this short description may clear the fog. Normally, the display acts like a window that can be positioned over the X-register, the ALPHA register, or some line of program memory. Here's a drawing that shows the display (in Decimal Inch Mode, FIX 2) positioned over the X-register:



It is not uncommon for the display to be filled with information that is stored nowhere else in the calculator. The display can be filled with information (the VIEW and AVIEW functions fill the display with information), and it can be used as a temporary holding place for this information.

The AECROM uses this "information holding" feature of the display in the units modes as well as in the functions DMS and LPS. Fractional, Decimal Meter, and Decimal Inch information are held in their current form only in the display (much like an error message or the "STO _ _ " you see midway through storing a number).

PROGRAMMING WITH THE UNITS MODES

As was just described, the units modes affect only the display. With the exception of the Decimal Foot mode, the numbers that you see in the display are not stored in the stack or in any HP-41 data register. They are stored only in the display.

This means that in writing programs for use with the units modes, you need to be aware of two things. First, any numbers that you key in as constants in your programs have to be in their *Decimal Foot* representation, regardless of the mode in which you plan to run the program. Results will be displayed in the appropriate mode, and numbers that you key in while running the program are keyed in the appropriate mode, but the constants in the program aren't converted. They go straight from program memory into the X-register, so they must be in Decimal Foot mode. (An example of programming with constants is shown on page 80.)

Second, the standard printer functions work with numbers that are stored in registers in the HP-41. No functions are available in the standard set of functions that allow you to print information stored in the display.

So, as a means around this, the AECROM comes prepared: The functions PRD, ACD, and PRAD, are designed specifically to help you print data that appears in the display only. These functions are described on pages 77 through 84 and some examples of programming using the units modes are given on those pages.

/CONV and *CONV

In Decimal Inch Mode and Decimal Meter Mode, if you wish to multiply or divide a measurement in the display by an integer value using the normal keystrokes, you will not get the correct answer. Because of the way the units modes store numbers, the functions /CONV and *CONV are provided for multiplication in these two modes.

Example: You're measuring a square room for molding. The measurement of one wall is around 65.5 inches. If you need to buy enough molding to complete four rooms of the exact same dimensions, how much should you buy?

Solution: In Decimal Inch Mode: 65.5 [ENTER] 4 [X] [XEQ] [ALPHA] /CONV [ALPHA] 4 [X] [XEQ] [ALPHA] /CONV [ALPHA] (1048.00).

Example: A piece of rope 11.4 meters long has to be divided into 7 equal pieces. How long will each piece be?

Solution: In Decimal Meter mode: 11.4 [ENTER] 7 [÷] [XEQ] [ALPHA] *CONV [ALPHA] (1.63).

Chapter 2. The Program Generator

The AECROM Program Generator (PROG) will translate your algebraic formulas into HP-41 programs. The programs that it produces are normal programs that show up in your CAT 1 listing. You can write them to cards, tape, extended memory, or any other mass storage media, and you can use these programs as subroutines in other programs. They are in every way, sense, and form, a normal HP-41 program.

The only thing unique about the programs that PROG produces is that they are created by the AECROM from algebraic formulas that YOU supply. With PROG, writing a program to solve an algebraic formula is just a matter of keying in that formula, just like it's written! You don't even have to put your HP-41 into program mode. The PROG function writes the program and stores it in memory for you to use.

A QUICK EXAMPLE OF PROG

Example: As a simple first example, use the PROG function to write a program called FRT to solve the formula:

FRUIT = APPLES + ORANGES

Solution:

KEYSTROKES	DISPLAY
[XEQ] [ALPHA] PROG [ALPHA]	PROG _
[ALPHA] FRT [ALPHA]	PACKING* ENTER:FORMULA
A [ ] [+] [ ] O	A+O
[R/S]	ENTER:LBL,CONS. A . .=
APPLES	A . .= APPLES
[R/S]	O . .=
ORANGES	O . .= ORANGES
[R/S]	ANS=
FRUIT	ANS=FRUIT
[R/S]	PROGRAMMING.. PACKING* RUN SIZE>=02

*If you get the message TRY AGAIN, you don't have enough RAM memory space for this small program. You need to either set your SIZE lower ([XEQ] [ALPHA] SIZE [ALPHA] 010, for example), or clear out one or more of the programs you have in your CAT 1 listing.

RUNNING THE PROGRAM

Make sure you are in Decimal Foot mode (press [XEQ] [ALPHA] >DF [ALPHA]), then run the program (press [R/S] or [XEQ] [ALPHA] FRT [ALPHA]). All of the examples in this chapter assume you're in Decimal Foot mode, unless they state otherwise.

Say that for this problem, you have 5 apples and 6 oranges and you want to know the total amount of fruit you have. When APPLES=? comes up in the display, press 5 [R/S]. For ORANGES=?, press 6 [R/S]. The calculator will temporarily display FRUIT= and then show you the answer: 11.0000.

A GENERAL DESCRIPTION

The above formula was simple, to say the least, but the procedure for using the PROG function will be no different when you use it for translating more complicated formulas into programs.

The four steps for creating programs using the PROG function are as follows:

1. Execute PROG and, at the prompt PROG _, supply the name for the program that you wish to appear in CAT 1.

2. Key in the formula correctly (only one side of an equation) using single letters to represent variable names. (Keying in formulas is explained in greater detail below.) Press [R/S] when you're finished.

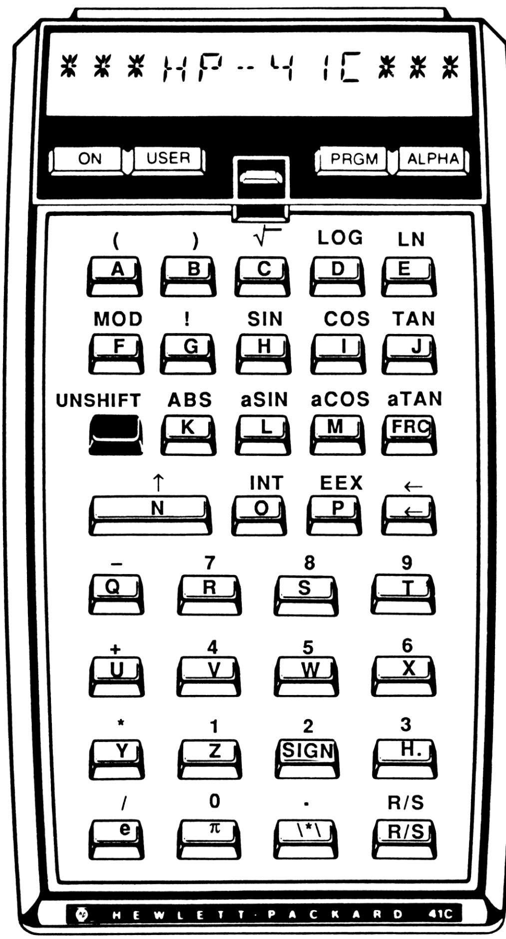
3. Name the variables and assign values to constants. Press [R/S] after each completed input.

4. If you want the answer to be labeled, key in a name. Press [R/S], and the AECROM writes the program.

The key step in the above four steps is number 2. You have to know a few things about how to correctly key in a formula. What functions are available and how do you key in functions? For example, how do you key in SIN (A)? Well, here are the details of keying in a formula:

A NEW KEYBOARD

When the display shows ENTER:FORMULA, the keyboard on the HP-41 has been redefined as follows:



At first glance, this keyboard appears very similar to the ALPHA keyboard. The letters are all each assigned to a key. The digits and arithmetic signs are available as shifted versions of the keys on which they're printed. But this keyboard is different from the ALPHA keyboard!

The best way to learn this new keyboard is to work with it. Execute PROG and, at the prompt PROG _, type [ALPHA] TEST [ALPHA] or any other name that you choose. The display will show ENTER:FORMULA.

Press the [W] key. A "W" comes up in the display. Now clear that away by pressing [←]. Now press [ ] [W]. A "5" comes up in the display.

Press the [W] key again. Another 5 comes into the display.

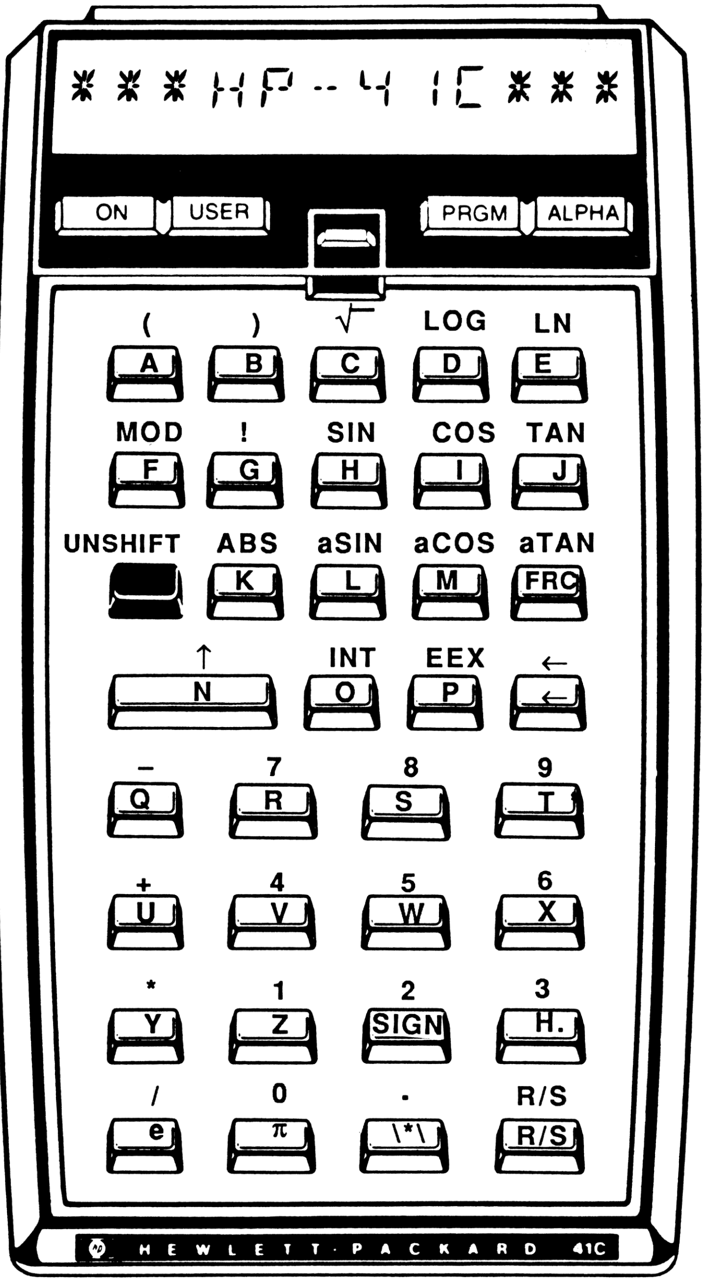
Notice that the SHIFT in the display hasn't cancelled. If you want the SHIFT to cancel, you have to press the shift key [ ]. This is different from the standard ALPHA keyboard, but it allows you to key in numbers like 5.775 without pressing the [ ] key five times.

Press [←] twice to clear those fives away, then with SHIFT on in the display press the [J] key. The shifted [J] key brings the TAN function into your formula.

Continue typing to complete the formula TAN(3A) + 0.75B + C. As you make mistakes (say what?), you can clear them away using the backarrow key. Refer to the keyboard illustrated on the previous page to locate characters for the above formula. Remember to press the [ ] shift key when necessary.

Switching back and forth from the shifted to the unshifted keyboard may seem a bit awkward at first, but for keying in formulas, you'll find this design to be very efficient.

Once you get the above formula keyed in correctly, press the [←] key repeatedly until you cancel the function completely. This shows you that if you respond to ENTER:FORMULA by pressing the [←] key, you exit the PROG function.


HP-41C
ON
USER
PRGM
ALPHA
( ) √ LOG LN
A B C D E
MOD ! SIN COS TAN
F G H I J
UNSHIFT ABS aSIN aCOS aTAN
K L M FRC
↑ INT EEX ←
N O P ←
– 7 8 9
Q R S T
+ 4 5 6
U V W X
* 1 2 3
Y Z SIGN H.
/ 0 . R/S
e π *\ R/S
HEWLETT · PACKARD 41C

KEYING IN FORMULAS

Here are a few things you should notice when you are working through the following example.

1. PROG accepts implied multiplication. That is, when you key in ABC, it assumes you mean A x B x C. This feature reduces the keystrokes required to key in most formulas.

2. After you finish keying in a valid formula, PROG will prompt you with ENTER:LBL,CONS, which means you need to name your variables and assign values to any constants. At this point, the keyboard is the same as above except that any non-character keys (like TAN, SIN, LOG) will be ignored.

3. Up to eight characters can be used to name a variable.

Example: The formula for the volume of a cylinder of a known inner-diameter and height is:

VOLUME = HEIGHT (π DIAM^2 / 4).

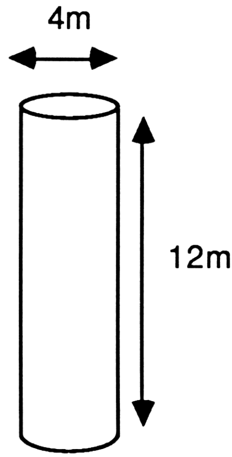
Create a program that takes the height and diameter of a cylinder and returns its volume. Don't label the answer. Name the program CYLVOL.

Solution:

KEYSTROKES	DISPLAY
[XEQ] [ALPHA] PROG [ALPHA]	PROG _
[ALPHA] CYLVOL [ALPHA]	PACKING*
	ENTER:FORMULA
H [ ] [(] [ ] D [ ] [^] 2 [ ] [π] [ ] [÷] 4 [)]	H(D^2 π /4)
[R/S] ENTER:LBL,CONS.	
	D . .=
DIAM	D . .= DIAM
[R/S]	H . .=
HEIGHT	H . .= HEIGHT
[R/S]	ANS=
[R/S]	PROGRAMMING.. PACKING* RUN SIZE>=03

By pressing [R/S] when the prompt ANS= comes up in the display, you are telling PROG not to label the answer. The RUN SIZE>= prompt tells you how many registers are required to run the program. RUN SIZE>=03 means you have to have at least three data registers available when you run this program ([XEQ] [ALPHA] SIZE [ALPHA] 003).

Example: Calculate the volume of a cylinder 4 meters in diameter by 12 meters high.



Solution: [R/S] (or [XEQ] [ALPHA] CYLVOL [ALPHA]) 4 [R/S] 12 [R/S] (150.7964 in FIX 4).

Example: Calculate the volume of a cylinder 2' 4–5/16" in diameter by 6' 3–1/2" high.

Solution: First, hold down the [ON] key and release it when FRACTIONAL is in the display. Then press [R/S] 2.04516 [R/S] 6.0312 [R/S]. The answer is 27' 6–1/16", but inches and fractions of an inch don't mean anything when you are dealing with cubic feet, right? (What good is it to know 12ths and 192nds of a cubic foot?)

To view the appropriate fraction of a cubic foot you have to switch to Decimal Foot mode. Hold down the [ON] key and release it when DECIMAL FOOT is in the display. This is the correct answer in cubic feet (27.5074).

LOW PRIORITY MULTIPLY (*\)

There's a function located on the [.] key that looks like this: *\. This function is called "low priority multiply." It does the same thing as the multiply function (X), but it is evaluated after the + and - signs in your formula.

The purpose of low priority multiply is to reduce the number of parentheses in a formula that you key in. It can also save you from having to start all over when you get to the end of keying in a formula and realize that the whole formula needs to be multiplied by some value that otherwise would require the formula to be enclosed in parentheses. The example in the following section shows the use of the low priority multiply function.

TRIG and HYPERBOLIC FUNCTIONS

The trigonometry functions and inverse trigonometry functions are easy to locate on the keyboard and are just as easy to use. You simply key them in as you would write them in your formula on paper. Only one keystroke is necessary to key in a trig or inverse trig function.

But, where are the hyperbolics? Ah, yes...these functions (SINH, TANH, and COSH, and their inverses) *were* included in the list of AECROM functions. You should be able to use them in your formulas, right?

Certainly. Notice that the unshifted version of the [3] key is the function "H." This key is used to turn a trig or inverse trig function into a hyperbolic.

Example: Execute PROG, name it TEST, and key in the formula ((SINH A)^2+(COSH A)^2) x X.

Solution: When the display reads ENTER:FORMULA, key in one of the following sets of keystrokes, either will work.

Set I: [ ] [(] [SIN] [ ] [H.] A [ ] [)] [^] 2 [+] [(] [COS] [ ] [H.] [B] [ ] [)] [^] 2 [ ] [*\] [X].

Resulting formula: (SINH A)^2 + (COSH A)^2 *\ X.

Set II: [ ] [(] [(] [SIN] [ ] [H.] A [ ] [)] [^] 2 [+] [(] [COS] [ ] [H.] [B] [ ] [)] [^] 2 [)] [ ] [X].

Resulting formula: ((SINH A)^2 + (COSH A)^2) x X.

Notice how the low priority multiply function (*\) reduces the number of parentheses in the resulting formula.

Finally, either press [R/S] to have PROG complete the program, or press the [←] key repeatedly until the function cancels.

DETAILS OF PROG

PROG is non-programmable. When you key in a formula at the ENTER:FORMULA prompt, PROG insists that you follow certain rules. These rules are listed below:

1. The first character in your formula cannot be a right parenthesis, MOD, factorial (!), +, x, or /. A minus sign can be used as the unary minus (for example, negative 5 can be entered as –5).

2. Constants may be entered either as digits in your formula or during the ENTER:LBL,CONS routine. If you wish to enter constants during the ENTER:LBL,CONS routine you need to include those constants as single letters in your formula.

3.

THESE FUNCTIONS	CAN BE FOLLOWED BY ANYTHING BUT
left parenthesis	+
square root (SQRT)	–
LOG	x
LN	/
MOD	FACT (!)
trig functions	right parenthesis
hyperbolic trig functions	MOD
FRC	
INT	
EEX	
^	
+	
–	
x	
/	
SIGN	

4. These functions (characters in your formula) can be followed by anything: The letters A through Z, e, π, low priority multiply (*\), right parenthesis, factorial (!), decimal point (.), and the digits 1 through 9.

When ENTER:LBL,CONS is displayed, up to eight characters can be keyed in to name a variable or to specify the value of a constant. You can choose to leave the single letter as the prompt for the variable (by just pressing [R/S]), key in a name for that variable, or key in a numeric constant.

If the first character in the name is a number or a + or – sign, PROG will take your input as a numeric constant. In a numeric constant, the character "E" is used to signify the exponent in scientific notation (1.2E6 means 1.2 x 10^6 or 1,200,000). Also, both a "," and a "." are accepted as the radix (1.2 is the same as 1,2 which is also the same as 1,200, so don't use commas for grouping).

When you execute PROG and get the prompt PROG_, you have to key in a name for the program that is going to be created. You can key in any ALPHA name up to seven characters long. PROG always uses this name as the global ALPHA label at the first line of the program.

If you use the single characters A through J or a through e, which are commonly used as local ALPHA labels, you will find that PROG still makes them into global ALPHA labels. They show up in CAT 1, but because the HP-41 expects these single letters to be local ALPHA labels, you can't access them using GTO or XEQ except, perhaps, in a synthetic program line (if you're into that sort of thing). In short, don't use those single letters as program names with PROG unless you enjoy the additional hassle.

CLEARING PROGRAMS

The programs created by PROG can be cleared by the same methods that you use to clear any program. The HP-41 function CLP and the extended function PCLPS are dynamite when it comes to clearing programs.

To clear the program labeled FRT (you keyed in this program back on page 30), press [XEQ] [ALPHA] CLP [ALPHA] [ALPHA] FRT [ALPHA].

To clear every program that you've put in your HP-41 since you keyed in the FRT program, put FRT in the ALPHA register (press [ALPHA] FRT [ALPHA]), then execute PCLPS ([XEQ] [ALPHA] PCLPS [ALPHA]). This only works if you have extended functions (either the HP-41CX or the X-Functions Module).

Chapter 3. The AECROM Curve Fitter

Two functions in the AECROM (^{T}CURVE and CRVF) are provided to help you fit your experimental data to various curves.

With the AECROM program "CURVE," you can fit an unlimited number of data pairs (x,y) to sixteen different curves. "CURVE" will automatically determine which of the sixteen curves best fits the supplied data or you can specify the curve to fit. Once the data has been fit to a curve, "CURVE" will return predicted y-values for x-values you supply.

An impressive feature of the "CURVE" program is its speed. It can find the best fit of the sixteen curves in less than one minute, so you won't waste much time staring at the display waiting for an answer. This speed is attributable to the CRVF function which is written in machine code in the AECROM. This function is available for you to use in writing your own curve fitting program (see page 55).

So, by using the "CURVE" program, you are essentially taking all the grind work out of fitting data to curves. You just enter the data pairs that need to be fit to a curve, and press one key.

Naturally, the explanation in this chapter is aimed primarily at developing your understanding of how to use the "CURVE" program. This isn't going to be a complete course on curve fitting or the statistical concepts involved in the process of fitting data to curves. The hope is that these are not completely new concepts. If they are completely new, other books are available on the subject of Curve Fitting. One particularly useful text is called *Curve Fitting For Programmable Calculators* by William M. Kolb. (If you can't find it, write SYNTEC, INC., P.O. Box 1402, Bowie, MD 20716 USA.)

A MENU DRIVEN PROGRAM

The program "CURVE" is menu driven, that is, it redefines the meanings of the top row of keys and those new meanings can be shown in the display above the keys. In order to use "CURVE," you must set your calculator to USER mode (press [USER] to turn on the word USER in the display) and you must clear any global assignments on the top row of keys.

CLEARING GLOBAL KEY ASSIGNMENTS

To clear global key assignments, press [ ] [ASN] [ALPHA] [ALPHA] and then the key you wish to clear. Or, if you have extended functions (or a CX), you can use CLKEYS to clear all key assignments.

USING CURVE

Press [XEQ] [ALPHA] CURVE [ALPHA] and the top row of keys takes on the following meanings:

[A] – (AD):	Accumulate an (x,y) Data pair.
[B] – (FIT):	Fit the Data to the curve specified in register 00 (curve number 0 – 15)
[C] – (Y=):	Calculate a y-value on the current curve for an input x.
[D] – (BST):	Find the BeST fit (of the sixteen available curves) for the current data.
[E] – (ME):	Bring up the MEnu.
[ ] [a] – :	Remove an (x,y) Data pair (for error corrections).

THE SIXTEEN CURVES

The sixteen curves available and their equations are listed below according to curve number.

0. LINEAR: y = a + bx
1. RECIPRCL (reciprocal of linear): y = 1 / (a + bx)
2. HYPERBLA (hyperbola): y = a + b/x
3. RECIP HY (reciprocal of hyperbola): y = x / (ax + b)
4. POWER: y = ax^b
5. MOD PWER (modified power): y = a b^x
6. ROOT: y = a b^1/x
7. EXPONENL (exponential): y = a e^(bx)
8. LOGRTHMC (logarithmic): y = a + b x LNx
9. LIN HYP (linear hyperbolic): y = a + bx + c/x
10. 2 ORD HY (second order hyperbolic): y = a + b/x + c/(x^2)
11. PARABOLA: y = a + bx + c(x^2)
12. LIN EXPN (linear exponential): y = ax/(b^x)
13. NORMAL: y = a e^(((x–b)^2)/c)
14. LOG NORM (log normal): y = a e^(((b–LNx)^2)/c)
15. CAUCHY: y = 1/(a(x+b)^2 + c)

DATA REGISTER USAGE

In order to run the "CURVE" program (or use the CRVF function), you need to have 56 registers available for data storage ([XEQ] "SIZE" 056). Registers 00 to 07 (below) are the ones that contain the information pertaining to the curve fit. Registers 08 to 55 (listed on page 55) contain the accumulated data information required to fit data to the sixteen curves.

R00 – Curve number (0 to 15)
R01 – a
R02 – b
R03 – c
R04 – RR (coefficient of determination)
R05 – RR corrected (for comparing curves of different orders)
R06 – Best RR corrected so far
R07 – Best curve number so far

Executing the CURVE program clears all data registers in the HP-41.

FINDING THE BEST FIT

Example: As a genetic engineer, you recently completed an experiment dealing with algae growth under varying levels of radiation. The experiment yielded nine data pairs which, after scaled and rounded to one significant digit, looked like this: (1,5) (3,7) (3,10) (4,9) (5,9) (5,11) (8,12) (10,10) (11,13).

What curve best fits these nine data pairs?

Solution: (Assumes FIX 4 and Decimal Foot Mode.)

KEYSTROKES	DISPLAY
[XEQ] [ALPHA] CURVE [ALPHA]	AD,FIT,Y=,BST,ME
5 [ENTER] 1 [A]	1.0000
7 [ENTER] 3 [A]	2.0000
10 [ENTER] 3 [A]	3.0000
9 [ENTER] 4 [A]	4.0000
9 [ENTER] 5 [A]	5.0000
11 [ENTER] 5 [A]	6.0000
12 [ENTER] 8 [A]	7.0000
10 [ENTER] [A]	8.0000
13 [ENTER] 11 [A]	9.0000

[E]	AD,FIT,Y=,BST,ME
[D]	LINEAR_ RECIPRCL_ HYPERBLA_ . . . LIN EXPN_ NORMAL_ LOG NORM_ CAUCHY_ LIN EXPN_

By pressing the [D] key, you told the CURVE program to determine which of the sixteen curves fits this data best. The calculator displays each curve name as it is fitting the data to that curve. When the search is completed, the name LIN EXPON_ is shown in the display to indicate that the data fits best to a linear exponential curve.

(The underline character "_" is there because of the way the name is loaded into the display during the program. The name stored in the ALPHA register doesn't include underline character.)

The equation for the LIN EXPON curve is y= ax/(b^x), and the values for "a" and "b" are stored in registers 01 and 02, respectively. If you press [RCL] 01, you will see 4.3859, which is the calculated value for "a." [RCL] 02 will show you 1.1476 which is "b."

FITNESS OF FIT

The coefficient of determination, (RR), is stored in register 04. As you know, this number is a score ranging from 0 to 1 that tells you how well your data fits to the specified curve. A score of 1 tells you that every data point falls exactly on the curve specified by a, b, c, and the curve's equation. If you press [RCL] 04, you should see the value 0.8767, which is RR for the previous example.

RR CORRECTED

The value for RR (described above) is dependent upon the number of data points in your sample and upon the number of coefficients (a, b, and c) that are estimated for a given curve. For this reason, RR is not often a good tool for comparing curves. However, a corrected version of RR, one that isn't dependent upon sample size or number of coefficients, has been provided (stored in register 05) for use when comparing different curves.

FITTING DATA TO A SPECIFIC CURVE

Example: Referring to the last example, as you continue your experiments, you come to the realization that the algae growth patterns under the given conditions are more closely modeled using the logarithmic relationship: $y= a + b(\ln x)$.

What are the values for "a" and "b," and what is the RR value using the nine data points in the previous example? This logarithmic curve is curve number 8.

Solution:

KEYSTROKES	DISPLAY
8 [STO] 00	8.0000
[E]	AD,FIT,Y=,BST,ME
[B]	LOGRTHMC

When you store the number 8 into register 00, you are specifying the curve to which you wish to fit the data. After fitting the data to the curve by pressing [B], the values a, b, and RR are stored in registers 01, 02, and 04, respectively. If you recall these values, you'll find that a = 5.1917, b = 2.8916, and RR = 0.7620.

As you can see, curve fitting using the CURVE program boils down to little more than keying in the data that you wish to fit. To start over, clearing all the previous data in registers, press [XEQ] [ALPHA] CURVE [ALPHA].

PREDICTING Y AT A GIVEN X

Example: As a metallurgist, you are testing a new additive to an alloy. This additive influences the strength of the alloy and this influence varies according to the percentage of the additive in the alloy. In tensile strength experiments, you measured failure points in wires of different additive percentages. The following table of scaled data was produced.

ADDITIVE %	FAILURE ÷ SCALE
0	1.000
0.5	1.131
1.0	1.079
1.5	1.354
2.0	1.382
2.5	2.350
3.0	3.767
3.5	3.945
4.0	4.165
4.5	4.629
5.0	4.811
5.5	5.577
6.0	5.391
6.5	4.735
7.0	4.618

Input the data and find the best fit (see page 49, if you don't know how to do this). Use the failure variables as the values of y and the percentages as the x's. Then, based on this best fit curve, find the scaled failure point for a wire with an additive percentage of 4.3.

Solution: The best fit is the NORMAL curve or NORMAL distribution (the equation is $y = a\ e\text{^}(((x-b)^2) \div c)$. The values for a, b, and c, are 5.173, 6.234, and −19.175.

Once you have determined this to be the curve, to get the y-value at x = 4.3, press 4.3 [E] [C]. That value is 4.256.

BST DISPLAY SHIFT (NOT ENOUGH DATA)

Occasionally, when you are using the BST key in the CURVE program to get the best fit of the sixteen curves, you will see one of the displayed curve names shift to the right in the display. This shifting indicates that not enough data have been accumulated to fit to that curve.

VIEWING THE MENU

In all of the curve fitting examples so far, the [E] has been simply an optional keystroke allowing you to see the menu before you proceed. You can press the [E] key anytime you wish to bring the menu into the display.

In the above example, when you pressed 4.3 [E] [C], the [E] key was included to show you that the [C] key represents the choice "Y=" which computes a predicted y-value for a given x.

USING THE CRVF FUNCTION

The CRVF function is the heart of the CURVE program. It is a machine language function that can both accumulate data and fit data to a specified curve.

You cannot change the way CRVF works, but you may wish to design your own program for curve fitting based on the CRVF function (i.e., a program to find the best fit of say three of the available curves). If you do, you'll need to know the details of CRVF that follow:

DETAILS OF CRVF (AND CURVE)

If flag 01 is clear, the CRVF function accumulates the values in the X- and Y-registers into registers 08 through 42, according to the following list:

r08– Σx	r25– n
r09– Σx^2	r26– $\Sigma y/x$
r10– Σy	r27– $\Sigma x/y$
r11– Σy^2	r28– $\Sigma x^2/y$
r12– Σxy	r29– $\Sigma y/(x^2)$
r13– n	r30– Σx^3
r14– $\Sigma 1/x$	r31– $\Sigma 1/(x^3)$
r15– $\Sigma 1/x^2$	r32– $\Sigma 1/(x^4)$
r16– $\Sigma 1/y$	r33– Σx^4
r17– $\Sigma 1/y^2$	r34– Σx^2y
r18– $\Sigma 1/xy$	r35– $\Sigma x\mathrm{LN}y$
r19– n (scratch)	r36– $\Sigma x^2\mathrm{LN}y$

r20- ΣLNx
r21- $\Sigma(LNx)^2$
r22- ΣLNy
r23- $\Sigma(LNy)^2$
r24- $\Sigma LNxLNy$

r37- $\Sigma(LNy)/x$
r38- $\Sigma xLNx$
r39- $\Sigma yLNy$
r40- $\Sigma(LNx)^2LNx$
r41- $\Sigma(LNx)^3$
r42- $\Sigma(LNx)^4$

If flag 01 is set, the CRVF function fits data to the curve (0 – 15) specified in register 00 and returns the parameters of the fit to registers 01 through 05 (see the list of registers on page 48).

Negative values of x or y in accumulated data pairs will be replaced by their absolute values. Any absolute value of x or y that is less than 1 E–09 will be replaced with 9.999999999 E–10.

CHANGING THE CURVE PROGRAM

The curve program can be copied into your HP-41's RAM and modified to fit your exact needs. Of course, you cannot modify anything in the ROM itself (i.e., you can't copy the changes you make in RAM back into the AECROM). But, you can save your new version of CURVE in extended memory or on cards to be run like any other HP-41 program.

To copy CURVE from the AECROM to RAM, press [XEQ] [ALPHA] COPY [ALPHA] [ALPHA] CURVE [ALPHA]. A documented listing of CURVE is provided in Appendix A.

DISPLAYING THE CURVE EQUATIONS

A simple HP-41 program called "EQ" has been included in Appendix A (along with barcode) to display the equation of the curve whose number is specified in register 00. Once EQ is loaded into RAM, it can be executed following a BST operation in the CURVE program (or after storing a curve number in register 00). EQ loads the equation corresponding to the number in register 00 (the best fit curve) into the ALPHA register and displays that equation (everything but "y=").

The EQ program has been provided for quick reference to the equation for a curve (given the curve's number). After using the BST operation, you still need to remember that register 01 contains a, register 02 contains b, and register 03 contains c.

–Notes–

Chapter 4. Geometric Solvers

Three functions in the AECROM can be called Geometric Solvers:

^{T}SARR	Slope, Angle, Rise, and Run Solver.
^{T}TRIA	Triangle Solver.
^{T}CIRC	Circle Solver.

These functions solve for unknown elements in the geometric shapes that they name. Key in the known elements **using some simple rules for inputting the knowns**, and one keystroke will solve for each of the unknowns.

These geometric solvers are all menu driven, which means that when the HP-41 is set to USER mode (press the [USER] key repeatedly and watch the USER annunciator turn on and off in the display), these functions change the meanings of the top row of keys on the HP-41.

What follows is a description of each of these three functions and some examples:

SARR- SLOPE, ANGLE, RISE, AND RUN SOLVER

The SARR function computes slopes, angles, rise and run. Your HP-41 must be in USER mode (press [USER]) and, if you have anything assigned to the top row of keys, you need to clear those assignments. (You may want to refer to page 46 here, if you don't know how to clear global key assignments.)

Example: The slope of a line is .776. What is the angle between the line and level?

Solution: In USER mode, press [XEQ] [ALPHA] SARR [ALPHA] [E] .776 [A] [B] (37.8115).

When you execute SARR and switch to USER mode, the keys in the top row take on new meanings. To see these new meanings press the [E] key in the top row. The calculator shows you the menu:

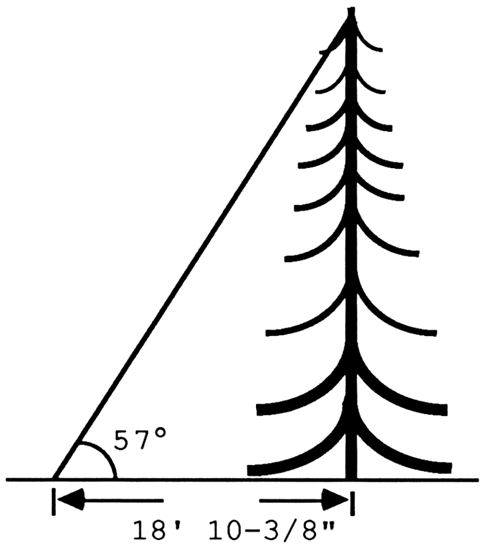
SL,AN,RI,RN,MENU

The first four keys in the top row represent the values SLope, ANgle, RIse, and RuN, and the fifth key calls the menu. Pressing one of the first four keys can mean either "take the value in the X-register as an input" or "calculate a value," depending on when you press it. When you key in a value and press one of the first four keys, the HP-41 takes it as an input. But immediately following an input, pressing one of the first four keys means "compute this value."

In the above example, the only known value was the slope which is all you need to know to solve for the angle. You simply keyed in the slope (0.776 [A]) and solved for the angle ([B]).

In the following example there are two known values so you need to pay attention to the order in which you input the knowns. When you're using SARR, **always input the knowns going from right to left in the menu.** Look at the following example:

Example: With a theodolite, you measured the angle of an imaginary line going from the top of a tree to the ground at a distance of 18' 10–3/8" from the base of the tree to be 57 degrees. How tall is the tree?



Solution: Assuming you just completed the previous example, press [XEQ] [ALPHA] >F [ALPHA] [E] (remember, you need to be in USER mode). Then 18.1038 [D] 57 [B] [C] will give you the answer (29' 0–9/16").

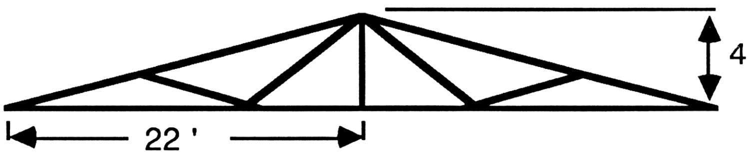
In the above example, you are solving for the Rise given the Run (18' 10–3/8") and the angle (57 degrees). Notice that when you key in a number before you press a key in the top row, the calculator takes it as an input. But when you press one of the top row keys without first keying in a number, the HP-41 calculates that value based on the numbers you've just keyed in.

To solve for any one of the four unknowns, you need to input knowns according to the following table. *(If you are familiar with Smoley's Tables, slope is the same thing as bevel.)*

To Solve for:	You need to input:
Slope	Run and Rise, or Angle
Angle	Run and Rise, or Slope
Rise	Run, and Angle or Slope
Run	Rise, and Angle or Slope

IMPORTANT RULE: Always key in your knowns from right to left in the menu.

Example: The center riser on a triangular roof truss is four feet high and the length from one end of the truss to the midpoint is 22 feet. What is the slope of the roof?



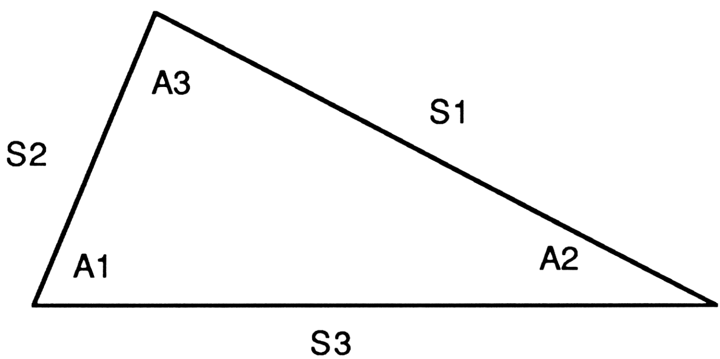
Solution: This solution assumes you have just completed the previous two examples and have already pressed [XEQ] [ALPHA] SARR [ALPHA].

Now, switch to Decimal Foot Mode ([XEQ] [ALPHA] >DF [ALPHA]). Then press [E] to view the menu and 22 [D] 4 [C] [A]. The answer is 0.1818.

TRIA - THE TRIANGLE SOLVER

From SARR, you can press [ ] [D] to execute the TRIA function or you can use [XEQ] [ALPHA] TRIA [ALPHA]. TRIA helps you solve all the characteristics of any triangle given three defining quantities for that triangle.

Here's a picture of an arbitrary triangle with its angles and sides labeled:



The sides are labeled in a counterclockwise order around the triangle and the angles are numbered according to the opposite side. This is the way that TRIA expects a triangle to be oriented.

Example: Call up the TRIA menu.

Solution: Execute the function TRIA then press [E]. Remember, the calculator must be in USER mode. You will see this menu:

S1,S2,S3,SARR,ME

The first three keys in the menu represent the three sides of the triangle, the SARR selection executes SARR (described starting back on page 59), and the ME shows you that the [E] key brings up the menu.

Now press [ ] [E]. You will see:

A1,A2,A3,AREA,ME

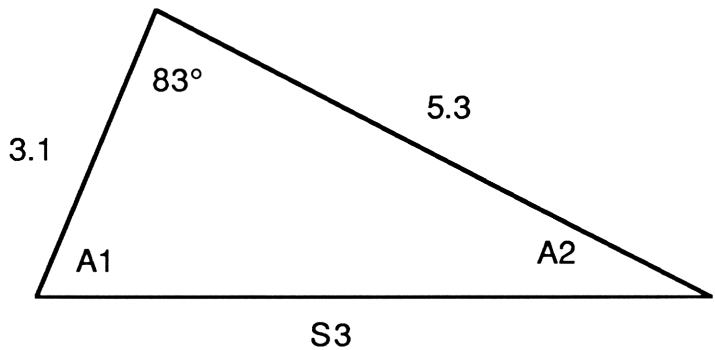
This is the shifted menu of TRIA. This menu shows you that by using the shifted top row keys ([ ] [A], [ ] [B], and [ ] [C]), you can input or solve for any of the three angles of a triangle. Plus, using the [ ] [D] key, you can solve for the AREA of a triangle.

So remember, the TRIA function has two menus. The [E] key calls up the unshifted menu, and [ ] [E] calls the shifted menu.

TRIA has fairly specific rules for inputting the three knowns that define a triangle. **Once the triangle is oriented similar to the previous diagram (sides labeled counterclockwise), the known values need to be input in counterclockwise order around the triangle as follows:**

KNOWNS	SUGGESTED INPUT ORDER
S S S	S1, S2, S3
A S A	A3, S2, A1
S A S	S1, A3, S2
S A A	S1, A3, A1
S S A	S1, S2, A1

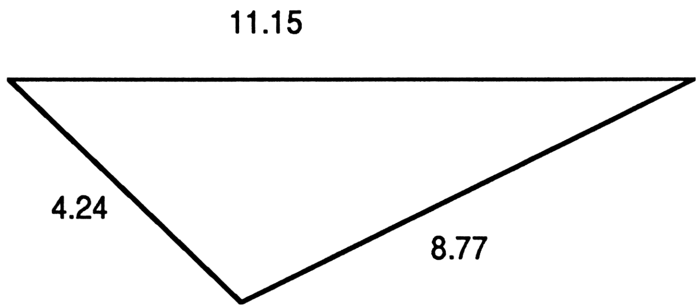
Example: Solve for all the unknown sides, unknown angles, and the area of the following triangle:



Solution: 5.3 [A] 3.1 [B] 83 [ ] [C]. Then press [ ] [A] to solve for A1 (64.9903), [ ] [B] to solve for A2 (32.0097), [C] to solve for S3 (5.8048), and [ ] [D] to solve for AREA (8.1538).

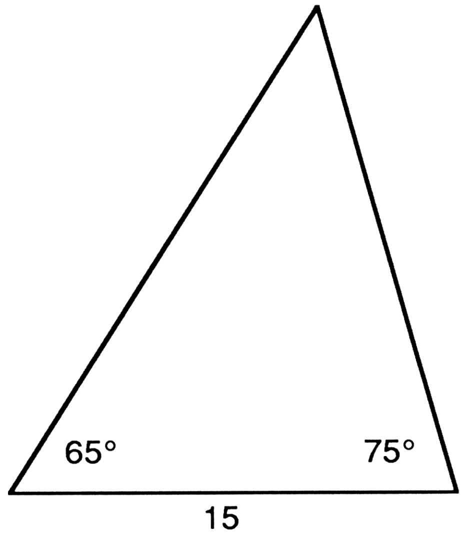
Once you have input the three defining knowns of a triangle, you can change one or two values at a time to see how the other lengths are affected.

Example: Given the following triangle with three known sides, calculate all the angles and the area of the triangle.



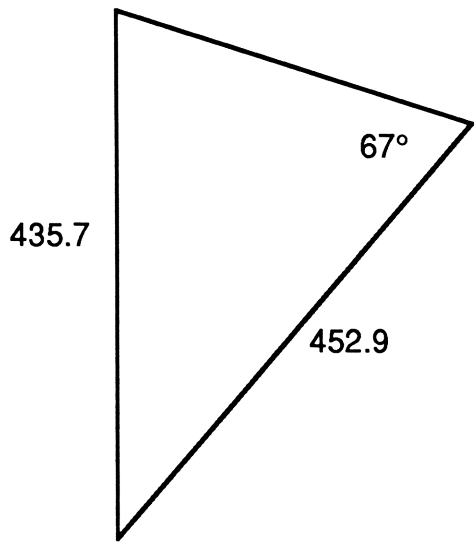
Solution: This is a S S S problem, so the input order is S1, S2, S3. With 4.24 as S1, A1 = 20.44°, A2 = 46.25°, A3 = 113.31°, and AREA = 17.07. Here are the keystrokes: 4.24 [A] 8.77 [B] 11.15 [C] [ ] [A] [ ] [B] [ ] [C] [ ] [D].

Example: Given the following triangle with two known angles and one known side, calculate the unknowns.



Solution: This is an A S A problem. So the input order is A3, S2, A1. With 15 as S2, press 65 [ ] [C] 15 [B] 75 [ ] A. Then press [A] to see S1 (22.54), [C] to see S3 (21.15), [ ] [B] to see A2 (40°), and [ ] [D] to see the area (153.22).

Example: Calculate the unknown characteristics of the following triangle:



Solution: This is a S S A problem, so the input order is S1, S2, A1. Once you have input this problem, the calculator displays the warning ANGL,SIDE,SIDE indicating that this combination of inputs can result in more than one solution. The calculator solves for the case where A2 is acute.

The keystrokes to input the triangle are 435.7 [A] 452.9 [B] 67 [ ] [A]. After the calculator displays ANGL,SIDE,SIDE, you can solve for the unknowns:

73.11 = A2
39.89 = A3
303.58 = S3
63,280.40 = AREA

MOVING BETWEEN TRIA AND SARR

Pressing the [D] key from the TRIA menu will execute the SARR function, and pressing [ ] [D] from SARR will execute TRIA. Data are transferred between the two functions as follows:

When going from TRIA to SARR, S1 becomes RUN, and S2 becomes RISE. The slope and angle are calculated accordingly.

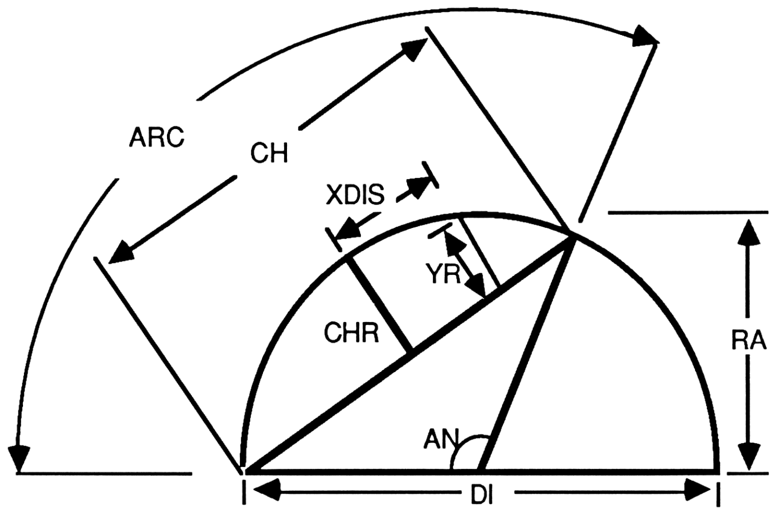
When going from SARR to TRIA, RUN becomes S1, RISE becomes S2, and A3 is set to 90.

If you transfer between SARR and TRIA using the [XEQ] [ALPHA] ... process, all the data are cleared.

CIRC - THE CIRCLE SOLVER

The CIRC function allows you to calculate properties of a circle and a sector of that circle from a known radius and central angle. Like the SARR and TRIA functions, the CIRC function is menu driven. The following diagram shows you some of the properties of a circle that can be calculated using CIRC.

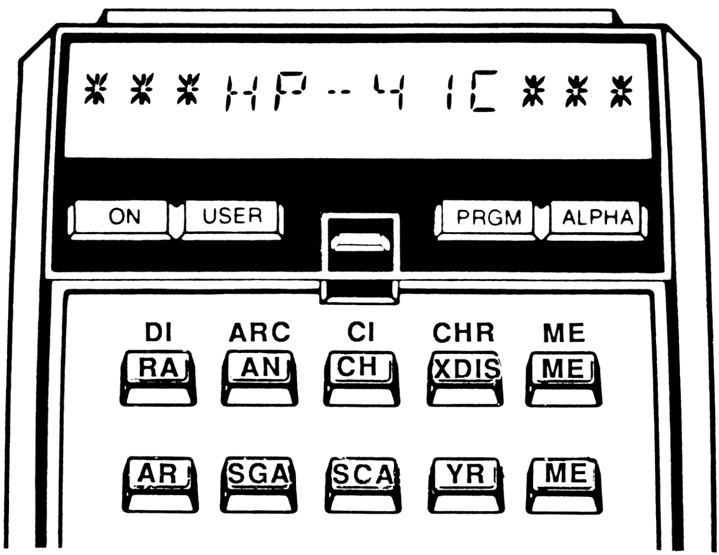
Important: The radius (RA), the sector angle (AN), and the X- distance (XDIS) are the only allowed inputs:



You can also calculate the circumference (CI) of the circle, the area (AR) of the circle, the segment area (SGA), and the sector area (SCA).

Three menus are available for CIRC. To view each menu, execute the function ([XEQ] [ALPHA] CIRC [ALPHA]) and press the [E], [ ] [E], and [J] keys.

The menu that comes up when you press the [E] key tells you the meanings of the top row keys, the menu on the [ ] [E] key applies to the shifted top row, and the [J] menu tells you the meanings of the keys in the second row.



Example: Calculate the diameter, area, and circumference of a circle with a radius of 10.0. Also, calculate the arc length, chord length, chord rise, sector area, and segment area of a sector in that circle with a central angle of 30 degrees.

Solution: With USER mode on and the display set to FIX 4, press [XEQ] [ALPHA] CIRC [ALPHA] [E] 10 [A] 30 [B]. Then...

To calculate	Press	See
diameter	[ ] [A]	20.0000
area	[F]	314.1593
circumference	[ ] [C]	62.8319
arc length	[ ] [B]	5.2360
chord length	[C]	5.1764
chord rise	[ ] [D]	0.3407
sector area	[H]	26.1799
segment area	[G]	1.1799

Also, you can calculate the rise (YR) between the circle and the chord for any known distance (X) along the chord from the center of the chord. (See the circle diagram on page 70.)

Example: Calculate the rise (YR) at X = 1.8.

Solution: 1.8 [D] [I] (0.1774)

Notice that the only values you can input are the radius (RA on the [A] key), the central angle (AN on the [B] key), and the X-distance (XDIS on the [D] key). These values must be knowns if you wish to calculate any properties that depend upon them.

Chapter 5. Hyperbolic Functions

The AECROM provides you with the following hyperbolic functions:

COSH	Hyperbolic Cosine
ACOSH	Inverse Hyperbolic Cosine
SINH	Hyperbolic Sine
ASINH	Inverse Hyperbolic Sine
TANH	Hyperbolic Tangent
ATANH	Inverse Hyperbolic Tangent

If you know how to use the standard trigonometric functions on the HP-41, you know how to use these hyperbolic functions. They operate on the number in the X-register, leaving the result in that register, without disturbing the rest of the stack.

The only difference between the way the AECROM hyperbolic functions work and the way the standard trig functions work is that the hyperbolic functions do not disturb the LASTX (L) register. The normal trig functions save the number they operate on in the LASTX register.

Example: What's the hyperbolic tangent of 0.375?

Solution: .375 [XEQ] [ALPHA] TANH [ALPHA]. The answer, in FIX 3, is 0.358.

Example: A tram at a popular ski resort in Colorado carries skiers between two different areas of the resort. The cable is attached at both ends at the same elevation with the angle between the cable and horizontal at the points of attachment equal to 47°. The horizontal distance between the two points of attachment is 1000 feet and the tram car travels at a contant speed of 15 feet per second. The formula for the travel time between the two end points is:

$$T = (1000\ \text{TAN}\ 47°) \div (15\ \text{SINH}^{-1}(\text{TAN}\ 47°))$$

where T is the time in seconds. What is T?

Solution: Make sure you are not in USER mode. Then press 1000 [ENTER] 47 [TAN] [x] [ ] [LASTx] [XEQ] [ALPHA] ASINH [ALPHA] 15 [x] [÷]. The answer is 77 seconds (76.74).

Example: Use the PROG function to create a program called TRAM from the above formula. Make the distance, angle, and speed all variables in the formula.

Solution: Press [XEQ] [ALPHA] PROG [ALPHA] [ALPHA] TRAM [ALPHA] and, at the prompt ENTER:FORMULA, press the following keys:

[ ] [A] [ ] [D] [ ] [TAN] [ ] A [ ] [B] [÷] [A] [ ] S [ ] [STO] [ ] [3] [ ] [A] [TAN] [ ] A [ ] [B] [R/S]

...to key in the formula...

(D TAN A) / (S aSINH.(TAN A)

Then, key in the variable names. At the prompt A..=, type ANGLE. At D..=, type DIST. At S..=, type SPEED. And at ANS..=, type TIME.

You will see the message: RUN SIZE >=05, telling you to have your SIZE set above five registers ([XEQ] [ALPHA] SIZE [ALPHA] 005). Press [R/S] to run the TRAM program. Test it using the numbers from the previous example.

–Notes–

Chapter 6. AECROM Utility Functions

PROGRAMMING WITH THE AECROM

The AECROM includes several functions (the units of length functions and the DMS, and LPS functions) that store results only in the display. They don't affect the X-register. Interesting implications arise when you include in your programs functions that work only with the display, because when a program is running, the display is often under the control of unseen forces.

Four functions have been included in the AECROM to help you write programs using functions that store their results in the display only. These functions are as follows:

ACD	Accumulates the display to the printer buffer (also see VIEWX).
PRAD	Prints the information in ALPHA left-justified and the information in the display right- justified also see VIEWX). If the number of characters in the display and ALPHA combined is greater than 24, the string in ALPHA will be truncated to trim the total characters back to 24.
PRD	Prints the display in a running program (also see VIEWX).

VIEWX	Converts the information in the X-register into the current units of length mode, and loads it into the display in a running program. Always precede the functions ACD, PRAD, and PRD with this function if you want the printed information to reflect the current units of length mode.
WAIT	Temporarily halts program execution to show you the information in the display. Use this function instead of PSE if you want to display information that has been loaded into the display by the VIEWX function.

Example: Write a short program that temporarily displays the number in the X-register in each of the four units of length modes. First display the number in Fractional Mode, then Decimal Inch Mode, then Metric Mode, and finally Decimal Foot Mode. Label the program "MODES."

Solution: Here's a listing. Bar Code for all the programs in this chapter appears in appendix A.

01 LBL ^{T}MODES
02 >F
03 VIEWX
04 WAIT
05 >DI
06 VIEWX
07 WAIT
08 >M
09 VIEWX
10 WAIT
11 >DF
12 END

The WAIT function pauses execution for about 0.5 second. If you want more time, use more than one WAIT in a row.

Had you used the PSE function at lines 03, 07, and 10, the HP-41 would have flashed the same number at you three times while the program was running. The HP-41 assumes control of the display during the PSE function.

Also, notice that the VIEWX function is not the same as the standard HP-41 program line VIEW X. The

AECROM function VIEWX is keyed in by pressing [XEQ] [ALPHA] VIEWX [ALPHA], whereas VIEW X is keyed in by pressing [XEQ] [ALPHA] VIEW [ALPHA] X (or [ ] [VIEW] X).

Example: As a clothing designer, you need to add a 7/8" seam allowance to any measurement you take. Write a program that adds 7/8" to any input. Design the program to run in Fractional Mode.

Solution: Here's the program listing:

```
01LBL ᵀSEAM
02 .875
03 ENTER
04 12
05 /
06 +
07 END
```

The important thing to remember here is that, even though the program is designed to run in Fractional Mode, the numbers in this program are in Decimal Foot Mode. The number you see in the display in Fractional Mode, is not the same number that is in the X-register. (See page 25 if you don't understand.)

Once you have the SEAM program keyed in, press [GTO] [ALPHA] SEAM [ALPHA], switch to Fractional Mode ([XEQ] [ALPHA] >F [ALPHA]), key in an input and press [R/S]. For an input of 2' 1-3/16" (2.01316, [R/S]), the answer should be 2' 2-1/16".

To make the above program print the result, add the following two lines:

```
07 VIEWX
08 PRD
```

...to the end of the program. VIEWX loads the result into the display in Fractional Mode format and PRD prints the display.

Example: As an engineer in an industry with a global market, you frequently find yourself having to include the equivalent decimal foot specifications, right along with metric specifications. Write a program that prints tenths of an inch, from one tenth to three inches, side by side with the metric equivalents (to the nearest millimeter).

Solution: Here's a documented program listing:

01 LBL ^{T}IN/M	Name the program whatever you like.
02 ^{T}METERS 03 CF 21 04 AVIEW 05 SF 21 06 ^{T}INCHES	Create a header for the output.
07 PRAD	Print the header. METERS is in the display and INCHES is in the ALPHA register. PRAD prints ALPHA left- justified, DISPLAY right-justified.
08 .1	Start at one-tenth of an inch.
09 >M	Switch to Metric Mode.
10 CLD	Clear the display of the AVIEWed contents (from line 04).
11 LBL 00	Start the loop.
12 FIX 3	Load the metric representation into
13 CF 21	the display. VIEWX pays attention to
14 VIEWX	the metric mode in transferring from
15 SF 21	X-register to display.

16 FIX 1	Set display for tenths of inches.
17 CLA	Load ALPHA with the inches. ARCL
18 ARCL X	ignores mode (it always transfers directly from the X-register to the display following to current FIX).
19 PRAD	Print the contents of ALPHA (the number in inches) left-justified and the display (the number in meters) right-justified.
20 .1	Add one-tenth to the number in the
21 +	X-register and compare the result to 3.
22 3	If greater than 3, quit looping.
23 X<>Y	
24 X<=Y?	
25 GTO 00	
26 >DF	Set Decimal Foot mode and FIX 4. (You
27 FIX 4	can change these lines to fit your own taste in mode and display format.
28 END	

The output of the above program on the HP 82162A printer looks like this:

```
INCHES      METERS
0.1          0.030
0.2          0.061
0.3          0.091
0.4          0.122
0.5          0.152
0.6          0.183
0.7          0.213
0.8          0.244
0.9          0.274
1.0          0.305
1.1          0.335
1.2          0.366
1.3          0.396
1.4          0.427
1.5          0.457
1.6          0.488
1.7          0.518
1.8          0.549
1.9          0.579
2.0          0.610
2.1          0.640
2.2          0.671
2.3          0.701
2.4          0.732
2.5          0.762
2.6          0.792
2.7          0.823
2.8          0.853
2.9          0.884
3.0          0.914
```

PRINTER UTILITY FUNCTIONS

Two other printer functions are included in the AECROM:

CLBUF: Prints and clears the printer buffer only if something is present in the buffer. This is something that can't be done with the standard functions.

(The function PRBUF prints the buffer and will print all blanks if the buffer is empty. The function ADV simply advances the paper.)

PLC Prints a line (24 characters long) of the first character in the ALPHA-register. Great for printing dividing lines of astericks or dashes in your printed outputs. If flag 12 is set for double-wide operation of the printer, PLC prints a line of only twelve characters!

DMS - DEGREES, MINUTES, AND SECONDS

The standard HP-41 function HMS (Hours, Minutes, and Seconds) is commonly used for working with degrees, minutes, and seconds. The AECROM includes a function (DMS) that is an improvement over HMS in the way that it displays Degrees, Minutes, and Seconds, in the way it handles certain conversions, and in the speed that it operates.

Example:

KEYSTROKES	DISPLAY
44.99999 [XEQ] [ALPHA] DMS [ALPHA]	45 0' 0"
[←]	44.9999
[XEQ] [ALPHA] HMS [ALPHA]	44.5960

As you can see, the DMS function correctly rounds the number in this case. The HMS function returns a correct number, but it doesn't correctly evaluate the whole minutes.

LPS - LONG PRECISION SECONDS

This function displays the seconds portion of DMS in the calculator's present FIX mode. It doesn't affect the X-register or any other register.

Example (FIX 4):

KEYSTROKES	DISPLAY
44.96123	44.96123
[XEQ] [ALPHA] DMS [ALPHA]	44 57' 40"
[XEQ] [ALPHA] LPS [ALPHA]	40.4280
[←]	44.9612

Notice that DMS and LPS don't change the number in the X-register.

–Notes–

Appendix A. Program Listings/BarCode

THE CURVE PROGRAM (DOCUMENTED)

The CURVE program performs all of the following curve fitting functions:

XEQ "A"	Adds point (X,Y) to all Σ registers (program lines 15–17).
XEQ "a"	Removes point (X,Y) from all Σ registers (program lines 18–24).
XEQ "B"	Fits entered data points to curve in register 00, calculating A, B, C, RR and corrected RR (lines 25–29).
XEQ "C"	Calculates Y given X for curve in register 00 (lines 53–183)
XEQ "D"	Finds curve that best fits entered data (lines 30–52).
XEQ "E"	Displays menu of choices (lines 9–14).

AD	Adds data point.
FIT	Fits curve.
Y=	Calculates Y for given X.
BST	Finds best curve.
ME	Displays menu

Upon entry to CURVE, or by pressing R/S from the menu, all summation registers are cleared. This happens in lines 1–6.

01♦LBL "CURVE"	Main entry.
02♦LBL 98	Entry for R/S pressed from menu.
03 CLST	Clear stack and all summation
04 CLRG	registers to start clean.
05 STO 55	Make sure that register 55 exists
06 GTO E	so that summations can be stored, then call menu.
07♦LBL 99	Main reentry after function has
08 STOP	completed. Display result and get function input.
09♦LBL E	"DISPLAY MENU" function.
10 "AD,FIT,Y=,BST,M"	Set up ALPHA to contain menu,
11 "⊢E"	and get function input
12 AVIEW	R/S pressed from menu–Clear
13 STOP	regs.
14 GTO 98	
15♦LBL A	"ADD POINT" function.
16 CF 00	Tell CRVF that this point is being
17 GTO 00	added.
18♦LBL a	"REMOVE POINT" funciton.
19 SF 00	Tell CRVF that this point is being
20♦LBL 00	removed.
21 CF 01	Tell CRVF to add/remove point, not compute.
22 CRVF	Add or remove point.
23 VIEW 13	Display the number of points entered.
24 GTO 99	Get next function input.
25♦LBL B	"FIT CURVE" function.
26 STO 00	Store the curve number in R00.
27 SF 01	Tell CRVF to compute.

28 CRVF	Go do the calculation for a, b, c, RR, RRcorr.
29 GTO 99	Get next function input.
30♦LBL D	"FIND BEST CURVE" function.
31 0	Initialize:
32 STO 06	the best RRcorr so far to 0 and:
33 STO 07	the best curve so far to 0.
34 .015	Set up ISG loop from 0 to 15 to
35 STO 00	test curves and save it as "current" curve number.
36♦LBL 97	Main fitting loop here.
37 RCL 00	Get curve number.
38 SF 01	Tell CRVF to compute.
39 CRVF	
40 RCL 06	Get best RRcorr so far and:
41 RCL 05	the RR corr for this curve.
42 X<=Y?	If this curve is:
43 GTO 00	better than any previous one,
44 STO 06	then save the RRcorr as the best,
45 RCL 00	and save the curve number as the
46 STO 07	best so far.
47♦LBL 00	End of loop to find best curve.
48 ISG 00	Do it for another curve?
49 GTO 97	Yes...
50 RCL 07	No–get the curve number of the best curve.
51 INT	Clean it up, then go fit this curve
52 GTO B	to the entered data points.
53♦LBL C	"CALCULATE Y" function.
54 GTO IND 00	Go to the correct calculation routine. Note that for these calculations, X is in the X register, Y is returned in the X register, a is R01, b is R02, c is R03.

$Y = a + bX$ STRAIGHT LINE

```
55♦LBL 00
56 RCL 02
57 *
58 RCL 01
59 +
60 GTO 00
```

$Y = \frac{1}{a + bX}$ RECIPROCAL

```
61♦LBL 01
62 RCL 02
63 *
64 RCL 01
65 +
66 1/X
67 GTO 00
```

$Y = a + b/X$ HYPERBOLA

```
68♦LBL 02
69 RCL 02
70 X<>Y
71 /
72 RCL 01
73 +
74 GTO 00
```

$Y = \frac{X}{aX + b}$ RECIPROCAL HYPERBOLA

```
75♦LBL 03
76 ENTER↑
77 ENTER↑
78 RCL 01
79 *
80 RCL 02
81 +
82 /
83 GTO 00
```

$Y = aX^{b}$ POWER

```
84♦LBL 04
85 RCL 02
86 GTO 01
```

$Y = ab^{1/X}$ ROOT

```
87♦LBL 06
88 1/X
```

$Y = ab^{X}$ MODIFIED POWER

```
89♦LBL 05
90 RCL 02
91 X<>Y
```

Common routine used by curves 4, 5, 6.

```
92♦LBL 01
93 Y↑X
94 RCL 01
95 *
96 GTO 00
```

```
 97♦LBL 07
 98 RCL 02
 99 *
100 E↑X
101 RCL 01
102 *
103 GTO 00
```

$Y = a\,e^{bX}$ EXPONENTIAL

```
104♦LBL 08
105 LN
106 RCL 02
107 *
108 GTO 01
```

$Y = a + b \ln X$ LOGARITHMIC

```
109♦LBL 09
110 ENTER↑
111 ENTER↑
112 RCL 03
113 X<>Y
114 /
115 X<>Y
116 RCL 02
117 *
118 +
119 GTO 01
```

$Y = a + bX + c/x$ LINEAR HYPERBOLIC

```
120♦LBL 10
121 ENTER↑
122 ENTER↑
123 RCL 03
124 X<>Y
125 X↑2
126 /
127 X<>Y
128 RCL 02
129 X<>Y
130 /
131 +
132 GTO 01
```

$Y = a + b/X + c/X^2$ 2ND ORDER HYPERBOLA

```
133♦LBL 11
134 ENTER↑
135 ENTER↑
136 X↑2
137 RCL 03
138 *
139 X<>Y
140 RCL 02
141 *
142 +
```

$Y = a + bX + cX^2$ PARABOLA

143♦LBL 01	Common routine used by curves 8, 9, 10, and 11.
144 RCL 01	
145 +	
146 GTO 00	
147♦LBL 12	$Y = aX/ b^X$ LINEAR EXPONENTIAL
148 ENTER↑	
149 ENTER↑	
150 RCL 02	
151 X<>Y	
152 Y↑X	
153 /	
154 GTO 01	
155♦LBL 13	$Y = a\, e^{(X-b)^2 + c}$ NORMAL
156 RCL 02	
157 CHS	
158 GTO 02	
159♦LBL 14	$Y = a\, e^{(b - \ln X)^2 + c}$ LOG NORMAL
160 LN	
161 CHS	
162 RCL 02	
163♦LBL 02	Common routine used by curves 13, 14.
164 +	
165 X↑2	
166 RCL 03	
167 /	
168 E↑X	
169♦LBL 01	Common routine used by curves 12, 13, 14.
170 RCL 01	
171 *	
172 GTO 00	
173♦LBL 15	
174 RCL 02	
175 +	
176 X↑2	
177 RCL 01	$Y = \dfrac{1}{a(X+b)^2 + c}$ CAUCHY
178 *	
179 RCL 03	
180 +	
181 1/X	
182♦LBL 00	Common end to all computation for Y=.
183 GTO 99	Go get next function input.
184 END	

```
01♦LBL "EQ"
02 XEQ IND 00
03 AVIEW
04 RTN
05 GTO "EQ"
06♦LBL 00
07 "a+bX"
08 RTN
09♦LBL 01
10 "1/(a+bX)"
11 RTN
12♦LBL 02
13 "a+(b/X)"
14 RTN
15♦LBL 03
16 "X/(aX+b)"
17 RTN
18♦LBL 04
19 "aX↑b"
20 RTN
21♦LBL 05
22 "ab↑X"
23 RTN
24♦LBL 06
25 "ab↑(1/X)"
26 RTN
27♦LBL 07
28 "ae↑(bX)"
29 RTN
30♦LBL 08
31 "a+bLNX"
32 RTN
33♦LBL 09
34 "a+bX+(c/X)"
35 RTN
36♦LBL 10
37 "a+(b/X)+(c/X↑2)"
38 RTN
39♦LBL 11
40 "a+bX+cX↑2"
41 RTN
42♦LBL 12
43 "aX/bX"
44 RTN
45♦LBL 13
46 "ae↑(((X-b)↑2)/c"
47 "⊢)"
48 RTN
49♦LBL 14
50 "ae↑(((b-LNX)↑2)"
51 "⊢/c)"
52 RTN
53♦LBL 15
54 "1/((a(X+b)↑2)+c"
55 "⊢)"
56 RTN
57 END
```

EQ

ROW 1: LINES 1-5

ROW 2: LINES 5-10

ROW 3: LINES 10-13

ROW 4: LINES 13-16

ROW 5: LINES 17-22

ROW 6: LINES 22-26

ROW 7: LINES 27-31

ROW 8: LINES 31-34

ROW 9: LINES 34-37

ROW 10: LINES 37-40

ROW 11: LINES 40-43

ROW 12: LINES 43-46

EQ

ROW 13: LINES 46-48

ROW 14: LINES 49-50

ROW 15: LINES 50-54

ROW 16: LINES 54-54

ROW 17: LINES 54-57

MODES

ROW 1: LINES 1-3

ROW 2: LINES 4-10

ROW 3: LINES 10-12

CYLVOL

ROW 1: LINES 1-2

ROW 2: LINES 2-5

ROW 3: LINES 5-16

ROW 4: LINES 17-19

IN/M

ROW 1: LINES 1-2

ROW 2: LINES 2-6

ROW 3: LINES 6-13

ROW 4: LINES 14-20

ROW 5: LINES 21-28

SEAM

ROW 1: LINES 1-3

ROW 2: LINES 4-7

TRAM

ROW 1: LINES 1-2

ROW 2: LINES 2-5

ROW 3: LINES 5-9

ROW 4: LINES 10-21

ROW 5: LINES 22-28

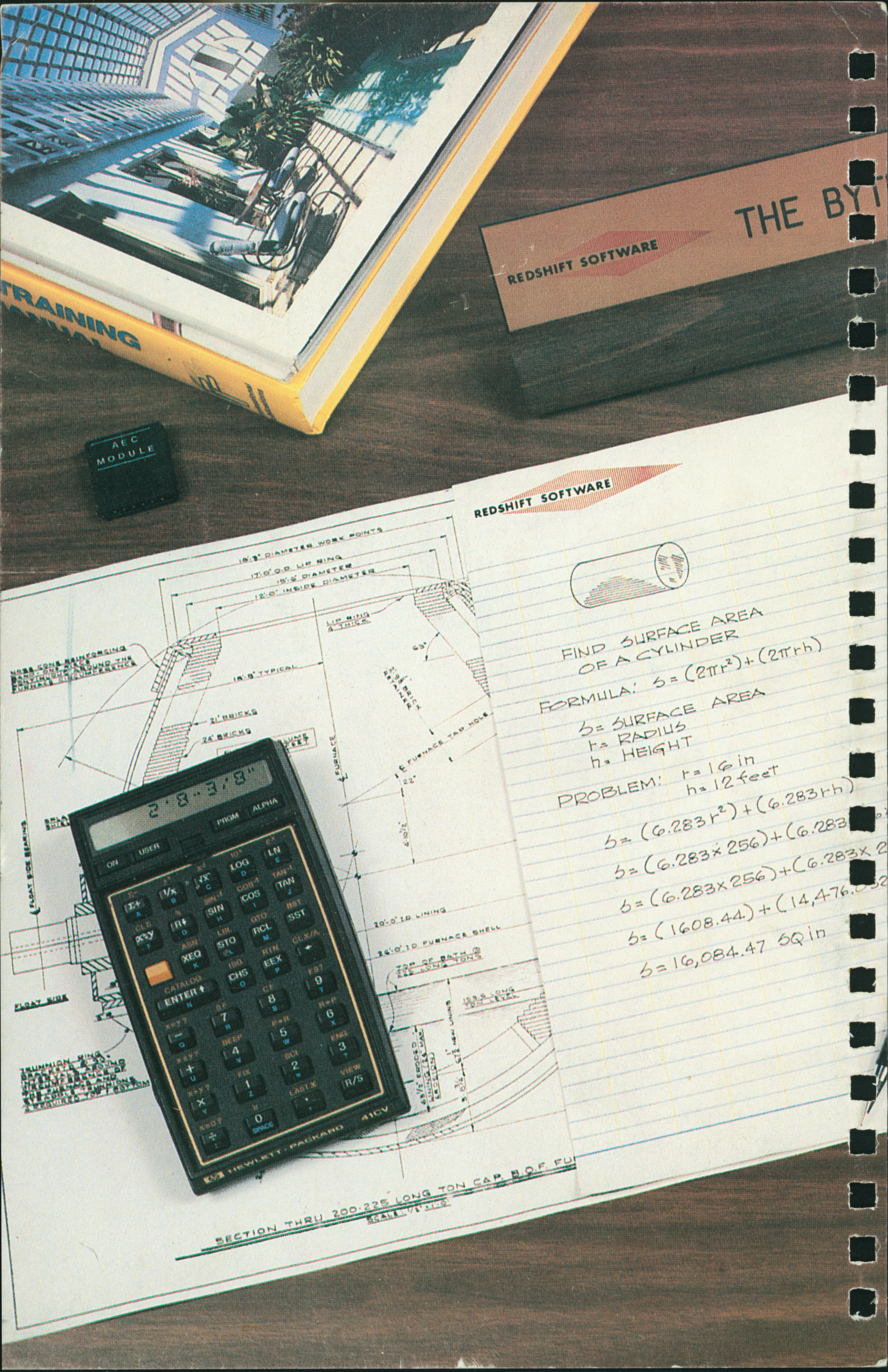
ROW 6: LINES 29-31

Function Index

Twenty seven functions.

XROM Number: 18

Index of Examples


REDSHIFT SOFTWARE
THE BY
AEC MODULE
TRAINING
REDSHIFT SOFTWARE
FIND SURFACE AREA
OF A CYLINDER
FORMULA: S = (2πr²) + (2πrh)
S = SURFACE AREA
r = RADIUS
h = HEIGHT
PROBLEM: r = 16 in
h = 12 feet
S = (6.283 r²) + (6.283 rh)
S = (6.283 x 256) + (6.283
S = (6.283 x 256) + (6.283 x 2
S = (1608.44) + (14,476.
S = 16,084.47 SQ in
SECTION THRU 200-225 LONG TON CAP. B.O.F. FU
HEWLETT·PACKARD
41CV