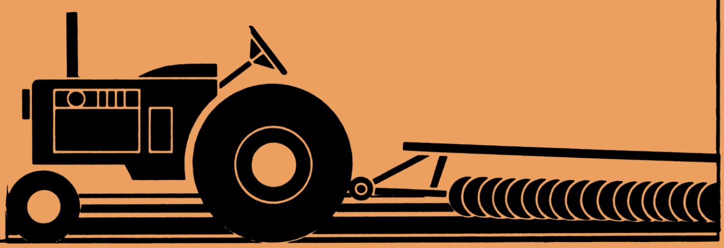
Field and Farmstead

Problems

For Pocket Calculators



FIELD AND FARMSTEAD PROBLEMS
FOR POCKET CALCULATORS

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AUSTERITY

Austerity Demands Precise Calculations
//////////////////////////////////////

This manual presents methods for using inexpensive pocket calculators on the farm. The topics covered are primarily operational in nature since most pocket calculators are not well suited for data storage or record keeping.

Although explanations are included with each problem type, complete understanding should not be required to use the keystroke sequences or programs. Readers who will be using the programs should, however, become familiar with the procedures for loading, editing, and executing programs by reviewing the calculator owner's manual and the material in Chapter 2.

In order to save space in the manual, the sequences and programs listed have been restricted to require input given in a single system of units. The required units of measure are all English, and hopefully the most appropriate have been chosen for each problem. Since the user might be working with a different set of units, a chapter on unit conversion has been included.

Readers who are already using computers are probably familiar with the old adage: "GARBAGE IN-GARBAGE OUT", and the same principle applies to pocket calculators. Precise and accurate results require precise and accurate inputs. Any required measurements must also be precise and accurate. All sequences and programs have been tested and should give correct results if properly used. DAG Publications assumes no liability in connection with the use of this manual.

NOTE FROM THE AUTHORS: If you have any suggestions for improving the manual, or if you have difficulty in using any of the material, please write us at the address below. We would appreciate any comments, and we would be happy to help you with any problems. In describing the problem, please be as specific as possible.

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Chapter 1

EQUIPMENT

INTRODUCTION

Over the past decade pocket calculators have proliferated to the extent that today few homes are without one. Many of the problems in this manual require no more than an ordinary six function calculator which can be bought for less than ten dollars. A few problems will require a scientific calculator, and the least expensive of these are around fifteen dollars.

Most of the problems for which programs are listed would be very time consuming if done by hand. (NOTE: In this manual, "by hand" means by keystrokes on a calculator without executing a program.) For intermediate problems, both keystrokes and programs are listed.

Although certain programmable calculators can be bought for around $50, a calculator with the capabilities required for our more involved problems will cost from $200 to $250. Programs listed in this manual are for Hewlett-Packard HP-41 series calculators.

Calculator Notation

Although the standard algebraic notation is by far the most common, a second type called Reverse Polish Notation (RPN) is growing in popularity. Keystrokes are listed in this manual for both algebraic notation and RPN, and both types are discussed in the following sections.

Algebraic Notation

Although there are specific characteristics which are different for different models (as described in the calculator operator´s manual), there are certain fundamental procedures which are the same for all calculators with standard algebraic notation. The most basic calculators have two working data registers which we will call the x- and y-registers. (NOTE: For the present, a "data register" is simply a place where the calculator stores a number.) A calculator with parenthesis keys has more than two working registers, and of course, a calculator with memory has one or more memory registers.

The four basic operations, ([+], [−], [X], [÷]) each utilize both the x-and y-registers, and most scientific calculators have the function y^x which also utilizes both registers. Other functions, such as x^2 , sin , ln , etc., operate only on the x-register. Although the contents of the x- and y-registers can be exchanged on some models, the number in the x-register is always displayed by the calculator.

The terminology "algebraic notation" arises from the keystroke sequence (i.e. the order in which the buttons are pushed), since it is the same as the order of symbols written in an algebraic equation. The following example illustrates:

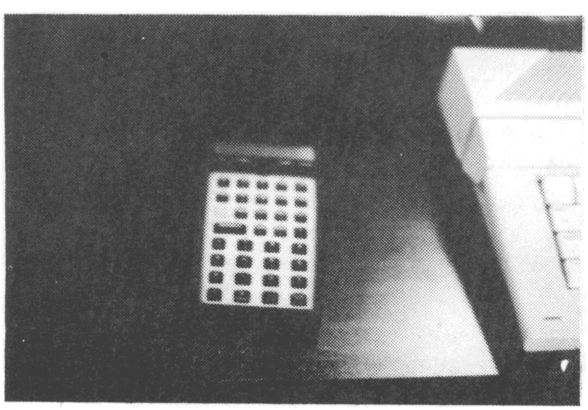
EXAMPLE: 35 - 7 = 28

1. The number 35 is keyed into the x-register.
2. The [−] key is pressed. This selects the operation (y - x) and copies the number 35 into the y-register. The x-register still contains the number 35, but it is now ready to receive another number.
3. The number 7 is keyed into the x-register replacing the number 35.
4. The [=] key is pressed. This completes the operation while copying the contents of the x-register into the y-register and copying the results of the operation into the x-register for display. The x-register now contains the number 28 (displayed), and the y-register contains the number 7. The number 35 is lost.

Notice that the keystrokes (35, [−] , 7, [=]) follow the same sequence as the characters in the algebraic equation.

From algebra class you may remember the mnemonic, "Please ecxuse my dear Aunt Sally.", which helps you to remember the hierarchy of algebra. A calculator with parenthesis keys follows this same hierarchy. Expressions within parentheses are evaluated first beginning with the inner sets and working outward. Multiplication and division are done next working from left to right. Addition and Subtraction are done last, again working from left to right. The keystrokes are in the same sequence as the corresponding characters are written in an algebraic equation. The only difference is that the calculator does not recognize implied multiplication. The [X] key must always be pressed between two quantities which are to be multiplied.

Reverse Polish Notation



The HP-41CV, pictured at left, is an example of a calculator with RPN. Although most readers are probably already familiar with algebraic notation, only a few hours of practice are required to master RPN, and RPN has several advantages which make the effort worthwhile. The only problem is that once you learn RPN, your old calculator will probably just collect dust. You will find that using the Hewlett-Packard automatic memory stack with RPN is far less confusing than using parenthesis keys on complicated problems. Although keystrokes in this manual are listed for both notations, you will notice that for the more involved problems, the RPN sequences are consistently shorter. In any case, understanding of RPN should not be required to use the sequences.

The HP-41CV has an automatic memory stack with four working registers (the x-, y-, z-, and t-registers). As in algebraic notation, the operations + , - , X , ÷ , and y^x use the x- and y-registers while the other functions operate only on the x-register. Examining the keyboard, however, you will discover there is no [=] key. You will notice the bar-shaped [ENTER] key which is used to tell the calculator when you are finished keying in a number. This is necessary when keying in two numbers sequentially (i.e. to seperate the numbers).

When a number is keyed into the calculator, it goes into the x-register, and the contents of the x-register are generally displayed. If you want to key in another number before performing an operation, you have to press the [ENTER] key. This terminates the entry of the first number and copies it into the y-register. The following example illustrates the operation of the automatic memory stack:

EXAMPLE: 1 + 2 + 3 + 4 = 10

Keystrokes	Operation
1	The number 1 is entered into the x-register. (x=1)
[ENTER]	Entry is terminated. The number 1 is copied into the y-register. (x=1, y=1)
2	The number 2 is keyed into the x-register, replacing the number 1. (x=2, y=1)
[ENTER]	Entry is terminated. The number 1 is copied into the z-register. The number 2 is copied into the y-register. (x=2, y=2, z=1)
3	The number 3 is keyed into the x-register, replacing the number 2. (x=3, y=2, z=1)

ENTER	Entry is terminated. The number 1 is copied into the t-register. The number 2 is copied into the z-register. The number 3 is copied into the y-register. (x=3, y=3, z=2, t=1)
4	The number 4 is keyed into the x-register, replacing the number 3. (x=4, y=3, z=2, t=1) NOTE: If we were to press the ENTER key again at this point, the number 1 would be lost off the top of the stack.
+	The operation (y+x) is completed with the result of (y+x) in the x-register and displayed. The memory stack rolls down, and the numbers 3 and 4 are lost from the stack. However, the number 4 is retained in the LASTX-register. (x=7, y=2, z=1, t=1)
+	The operation (y+x) is again completed with the result of (y+x) (i.e. 2 + 7) in the x-register and displayed. The memory stack rolls down, and the numbers 2 and 7 are lost from the stack. The number 7 is retained in the LASTX-register. (x=9, y=1, z=1, t=1)
+	The operation (y+x) is again completed with the result of (y+x) (i.e. 1 + 9) in the x-register and displayed. The memory stack rolls down. The number 9 is lost from the automatic memory stack, but is retained in the LASTX-register. (x=10, y=1, z=1, t=1)

Displays

Scientific notation for calculator displays enables the calculator to display very large and very small numbers. For instance, suppose you collect 6 topsoil samples per acre, each sample being one square foot in area. Now suppose that the 6 samples together contained 18,000 of the species nematodus eatumuppus. This would correspond to a population of 130,680,000 per acre. Notice that nine digits are required to write this number. A calculator with a fixed-decimal display of only eight digits would not be able to display such a large number.

Now suppose we write 130,680,000 as 1.3068×10^{8} This is called scientific notation. The 1.3086 is called the "mantissa" and the power to which we raise the multiplying factor is called the "exponent". Many calculators omit the 10 in the display, and the number is displayed 1.3068 08 .

To get back to fixed-decimal notation, just move the decimal point in the mantissa 8 places to the right and drop the multiplying factor. (i.e. 130,680,000). If the exponent is negative, move the decimal point to the left. A negative exponent means the number is very small.

When a number is written in scientific notation there is always just one digit to the left of the decimal point. There is another type of notation used by calculator displays in which there can be one, two, or three digits to the left of the decimal point. This is called engineering notation, and in this case the exponent is always a multiple of 3.

On many calculators you can choose between fixed decimal, scientific notation, or engineering notation. If you choose fixed decimal, the calculator automatically shifts to scientific notation when the number displayed is either too large or too small to write as a fixed decimal number. Some examples follow:

Display		Corresponding Number
1.795	11	179,500,000,000
6.626	-06	.000006626
130.6	06	130,600,000

(engineering notation)

Chapter 2

PROGRAMS

Introduction

A programmable calculator enables the operator to record a sequence of keystrokes. The calculator can execute this sequence or "program" much faster than you can do it by hand. It should be obvious at this point that a program can save you a lot of work, especially when you do the same calculation a number of times for different inputs.

Programs can contain "loops" whereby the calculator can do the same calculation and/or different calculations many times within the same program. In short, problems that could take you days, or even weeks to do by hand with an ordinary calculator can be completed in a matter of seconds by executing a good program.

Generally, different calculator models operate somewhat differently when it comes to programming. The programs in this manual are written for Hewlett-Packard HP-41 series handheld computers*, and these models were chosen because of some very significant advantages which are listed below:

(1) LARGE MEMORY- The HP-41CV and HP-41CX have sufficient memory to store several long programs simultaneously, along with the data storage registers needed to execute them. The HP-41C has less memory, but it can be updated with plug-in memory modules.

(2) SIMPLE PROGRAMMING- The HP automatic memory stack, RPN, mathematical functions, loop control functions, automatic line numbering, and other features all provide for simple programming. HP-41 programs for the more difficult problems will be consistently shorter than programs for other models. With fewer program steps, less program memory is required.

(3) EASY EDITING- It is an extremely simple matter to step through programs, erase program lines, and insert new lines with HP-41 series calculators. The lines are renumbered automatically.

(4) ALPHABETIC CHARACTERS- Comments can be included in HP-41 programs to ask the user for specific input or to label output.

(5) CONTINUOUS MEMORY- You can fill up the memory of an HP-41 series calculator with programs and data and then turn the calculator off. Whenever you turn it back on, whether a month or even a year later (as long as the batteries are still good), it's all still there,

just like you left it, and ready to use.

(6) USER KEYBOARD- Program labels can be assigned to specific keys on the HP user-defined keyboard. This allows you to begin execution of a program by pressing a single key.

(7) LIQUID CRYSTAL DISPLAY- this feature, which is shared with several other calculators presently in production, greatly extends the life of the batteries.

* Hewlett-Packard Company refers to these as "hand held computers", and in this manual we will use this terminology interchangeably with "programmable calculators". We could also call them "calculating computers" to distinguish them from the microcomputers which have become popular for farm record keeping.

NOTE: If you use one of these calculators in the field, a good accessory would be a touchpad (about $20) to keep dust out of the keys.

Loading Programs (See also your owner's manual.)

The first things you will need to know are how to change from one keyboard to another and the purpose of each keyboard.

Normal and shifted normal keyboards: Used to key in numerical data and to load some of the calculator's operations into the memory. The functions for the shifted normal keyboard are written in gold above each key. To shift, between these two, just press the gold SHIFT key. When you are on any of the shifted keyboards, the SHIFT annunciator appears in the display.

Alpha and shifted alpha keyboards: Used to key in "strings" of words (comments), labels, and the names of functions which are not on the normal or shifted normal keyboards. The characters for the alpha keyboard are written in blue on the bottom of the keys. The characters for the shifted alpha keyboard can be found above the keys on the table on the back of the calculator. To go to or from the Alpha keyboard, just press the ALPHA toggle key. When you are on the alpha keyboard, the ALPHA annunciator appears in the display.

User and shifted user keyboards: You decide how they can be used. This would be handy if the same function appears several times in the program you are loading. To make an assignment, press ASN then ALPHA then key in the name of the desired function, then ALPHA again, and then press the desired key. To go to or from the user keyboard, just press the USER toggle key.

NOTE: Both the ALPHA and USER annunciators can be lit at the same time, but the alpha keyboard takes precedence over the user keyboard.

Many of the calculator's functions can be loaded simply by pressing the appropriate keys on the normal keyboards. To load functions which do not have a key, just press XEQ and then go to the alpha keyboard and type in the name of the function. Pressing ALPHA again completes the program line. As an example, consider how you would load the calculator's factorial function as a program step:

PROGRAM LISTING	LOADING KEYSTROKES
FACT	XEQ ALPHA FACT ALPHA

A program line can also call functions which you load into the calculator yourself. We will refer to these as "subroutines", and they are really just combinations of functions which the calculator already knows. You could call them sub-programs. For example, suppose you have loaded a subroutine into the calculator memory under the label "FF". In the main program listing the label will be enclosed in quotation marks, and in the calculator display it will be preceded by a raised T. When loading a program, you can just replace the opening and closing quotation marks by the ALPHA toggle key.

MANUAL LISTING	DISPLAY LISTING	LOADING KEYSTROKES
XEQ "FF"	XEQ ^{T}FF	XEQ ALPHA FF ALPHA

A program line can be a comment or string. These are loaded in a similar manner, but you don't press the XEQ key. As an example, consider a comment line which asks the user to key in specific input data:

MANUAL LISTING	DISPLAY LISTING	LOADING KEYSTROKES
"TOTL ACRS=?"	^{T}TOTL ACRS=?	ALPHA TOTL ACRS=? ALPHA

Another important consideration is to have the calculator operating in the proper "mode" for loading programs. The calculator can be in either the "execution mode" or the "program mode". You can switch back and forth between these modes by pressing the PRGM toggle key, and whenever the calculator is in program mode, the PRGM annunciator appears in the display.

Perhaps the procedure for loading programs can best be learned by going through an example. The following program calculates the volume of an ordinary right circular cylinder:

D=diameter

L=length

V=volume=$\pi D^2L/4$

Program "CLNDR" (minimum SIZE=001)

NOTE: The minimum SIZE will be listed at the beginning of each program listing, but it is not part of the program.

PROGRAM LISTING	LOADING KEYSTROKES
	XEQ ALPHA SIZE ALPHA 001

This step is not always necessary. The SIZE function allocates memory for data registers. Executing Program CLNDR requires only one data register, so you can leave the rest of the memory available for programs. If you are not short on memory, you can just allocate a large SIZE and forget about it.

GTO . .

This takes you to the end of any programs already in the memory, "packs the memory, and ensures there is an END statement just before your program.

PRGM

This gets you into the calculator's program memory.

01 LBL "CLNDR"   LBL ALPHA CLNDR ALPHA

This line names the program. All programs and subroutines need "labels". A label in program memory is like a name in a phone book. Notice that you do not have to key in the line number. The calculator numbers the lines automatically.

02 "DIAMETER=?"   ALPHA DIAMETER=? ALPHA

03 PROMPT   XEQ ALPHA PROMPT ALPHA

04 x^2 x^2

Functions on the normal or shifted normal keyboards are easy to load.

05 "LENGTH=?"   ALPHA LENGTH=? ALPHA

06 PROMPT   XEQ ALPHA PROMPT ALPHA

07 *   X

In the listings and also in the display, a multiplication sign looks like an asterisk.

08 PI	[π]
09 *	[X]
10 4	4
11 /	[÷]

In the listings and also in the display, division is represented by a slash.

12 STO 00	[STO] 00
13 "VOLUME="	[ALPHA] VOLUME= [ALPHA]↙
14 ARCL 00	[ALPHA]↙ ARCL 00 [ALPHA]↙
15 AVIEW	[ALPHA]↙ AVIEW [ALPHA]

Alpha recall, ARCL, and alpha view, AVIEW, are loaded with keys on the shifted alpha keyboard. See the table on the back of the calculator. NOTE: The [ALPHA] 's with arrows are not really necessary since we stay on the alpha keyboards from line 13 to line 15.

16 END	[GTO] [.] [.]

This step inserts an END statement and packs the program. End statements are needed to separate programs in memory. Packing just closes up any gaps so there will be no wasted space in program memory.

[PRGM]

This takes us back to execution mode.

Editing Programs (See also your owner's manual.)

Suppose program CLNDR is somewhere in your program memory, and you want to check to make sure you loaded it correctly. This is a simple procedure with HP-41 series calculators, even if you need to change something.

The first thing you want to do is to locate program CLNDR. There are two easy ways to do this:

(1) Use the following keystrokes:

[GTO] [ALPHA] CLNDR [ALPHA]

(2) Run through "catalog 1" until you get to program CLNDR, and then stop the catalog:

[CATALOG] 1

To make sure you don't miss it, just stop the catalog as soon as it starts.

[R/S]

Then step through the catalog by pressing the single-step key until you find it.

[SST] , [SST] , ...

Now that you are at the right door, you want to enter the program memory (i.e. you want to switch to program mode).

[PRGM]

Once you are in program mode, you should be at the first line of program CLNDR. Now you can move forward and backward within the program by pressing the single-step and back-step keys, respectively.

[SST] , [BST]

If you single-step past the END statement or backstep past the LBL statement, you will stay in the same program (just going around again). If you find a line you want to remove, just press the CLEAR key.

If you want to add a line, just load it in the usual manner. The line numbers are changed automatically. When you are finished editing, go back to the execution mode.

[PRGM]

Executing Programs (See also your owner's manual.)

Although programs can use data stored in registers before execution, all programs in this manual will ask the user for data. The program will stop and ask for a specific number. The user will enter the number and then restart the program by pressing the RUN/STOP key. These "prompts" will be accompanied by a single aural tone. The output will be labeled in a similar manner, and it will be accompanied by a four tone aural "beep".

You can start the execution of program CLNDR with the following keystrokes:

[XEQ] [ALPHA] CLNDR [ALPHA]

If you are running a program repeatedly, you may want to assign it to a key on a user keyboard:

[ASN] [ALPHA] CLNDR [ALPHA] (desired key)

Now whenever you are on a user keyboard, you can start execution of program CLNDR simply by pressing one key.

NOTE: If you execute one of the regular calculator functions from a user keyboard, you may think the key is not working correctly. But there is nothing wrong with the calculator. It just takes the calculator a little time to find the function from the user keyboard.

After the program starts running, it will stop whenever it needs input, or whenever it displays output. After supplying the requested input or reading the output, just press the RUN/STOP key to restart the program.

Chapter 3

UNIT CONVERSIONS

Introduction

If you have inputs in units different from those called for in a keystroke sequence or program, you may need one of the conversion factors listed below. An example will illustrate the use of the table.

EXAMPLE: Suppose you know the volume of a gravity box in cubic feet, and you want to convert this volume to US bushels. From the table, we find the multiplying factor, .80356 to get from cubic feet to bushels (i.e. there are .80356 US bushels per cubic foot). If the volume of the box is 180 cubic feet, then

$$(180 \text{ ft.}^3)(.80356 \text{ bu./ft.}^3) = 144.64 \text{ bu.}$$

Algebraic	RPN
1. 180 ($ft.^3$)	1. 180 ($ft.^3$)
2. X	2. ENTER
3. .80356 ($bu./ft.^3$)	3. .80356 ($bu./ft.^3$)
4. =	4. X
144.64 (bu.) displayed	144.64 (bu.) displayed

On occasion, you might need to make chain conversions. Another example will illustrate.

EXAMPLE: Suppose you decide to convert an old water tank into a seed hopper. You know the volume in gallons, and you want to convert to bushels. Suppose you don't have a factor to convert from gallons to bushels, but you do have a factor to convert from gallons to cubic feet and another factor to convert from cubic feet to bushels. If the volume of the tank is 400 gallons, then

$$(400 \text{ gal.})(.1337 \text{ ft.}^3/\text{gal.})(.80356 \text{ bu./ft.}^3) = 42.97 \text{ bu.}$$

Algebraic	RPN
1. 400 (gal.)	1. 400 (gal.)
2. X	2. ENTER
3. .1337 ($ft.^3$/gal.)	3. .1337 ($ft.^3$/gal.)
4. X	4. X
5. .80356 ($bu./ft.^3$)	5. .80356 ($bu./ft.^3$)
6. =	6. X
42.97 (bu.) displayed	42.97 (bu.) displayed

In the examples above, we used the conversion factor .80356 $bu./ft.^3$ for changing from cubic feet to bushels. Suppose you want to go from bushels to cubic feet instead. In this case, you just use the inverse of .80356 $bu./ft.^3$, or 1.2446 $ft.^3$/bu. If your calculator has a [1/x] key, you can just key in .80356 and then press [1/x] to get the conversion factor to go from bushels to cubic feet. Otherwise, you can just key in 1 and then divide by .80356. Another example will illustrate.

EXAMPLE: Suppose you are converting part of your shop space to emergency grain storage. You have a space 30 ft. wide and 40 ft. long where you need to store 6,000 bu., and you want to know how high to make the walls.

$$(6000 \text{ bu.})\left(\frac{1}{.80356 \text{ bu./ft.}^3}\right) = 7466.77 \text{ ft.}^3$$

Then,

$$\text{Height} = \frac{7466.77\ \text{ft.}^3}{(30\ \text{ft.})(40\ \text{ft.})} = 6.22\ \text{ft.}$$

Algebraic	RPN
1. 1	1. 1
2. ÷	2. ENTER
3. .80356 (bu./ft.^{3})	3. .80356 (bu./ft.^{3})
4. =	4. ÷
1.24446 (ft.^{3}/bu.) displayed	1.24446 (ft.^{3}/bu.) displayed
5. X	5. 6000 (bu.)
6. 6000 (bu.)	6. X
7. =	7466.77 (ft.^{3}) displayed
7466.77 (ft.^{3}) displayed	7. 30 (ft.)
8. ÷	8. ÷
9. 30 (ft.)	9. 40 (ft.)
10. ÷	10. ÷
11. 40 (ft.)	6.22 (ft.) displayed
12. =	
6.22 (ft.) displayed	

Table of Conversion Factors

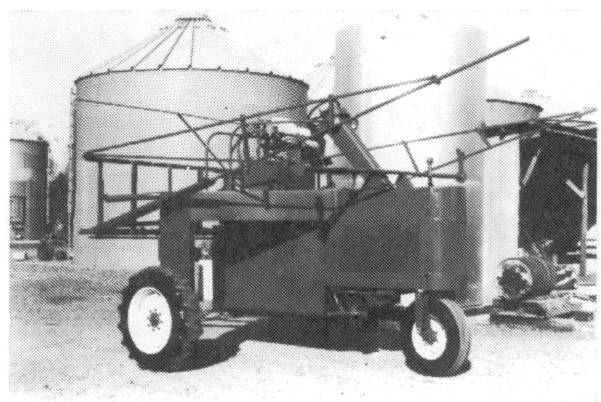
acres =	square ft.X .00002296	square mi.X 640	square metersX .0002471	hectaresX 2.471
bushels =	cubic ft.X .8036	cubic in.X .0004650	pecksX .25	litersX .02838
cords =	cubic ft.X .007813	cubic in.X .00000452	cubic yd.X .2110	cubic metersX .2761
cubic yards =	cubic ft.X .03704	cubic in.X .00002143	gallonsX .004951	cubic metersX 1.308
fluid ounces =	gallonsX 128	litersX 33.82	millilitersX .03382	cubic in.X .5540
gallons =	cubic ft.X 7.479	cubic in.X .004329	fluid oz.X .007813	litersX .2642
horse-power =	ft.-lb./sec.X .001818	Btu/min.X .02356	kilowattsX 1.341	metric hpX .9862
miles per hr. =	ft./minX .01136	ft./sec.X .6817	km/hr.X .6215	meters/min.X .3729
watt-hours =	BtuX .2929	ft.-lbs.X .0003767	hp-hrs.X 746.3	kilowatt-hrs.X 1000

Chapter 4

BOOM HEIGHT AND SPRAYER CALIBRATION

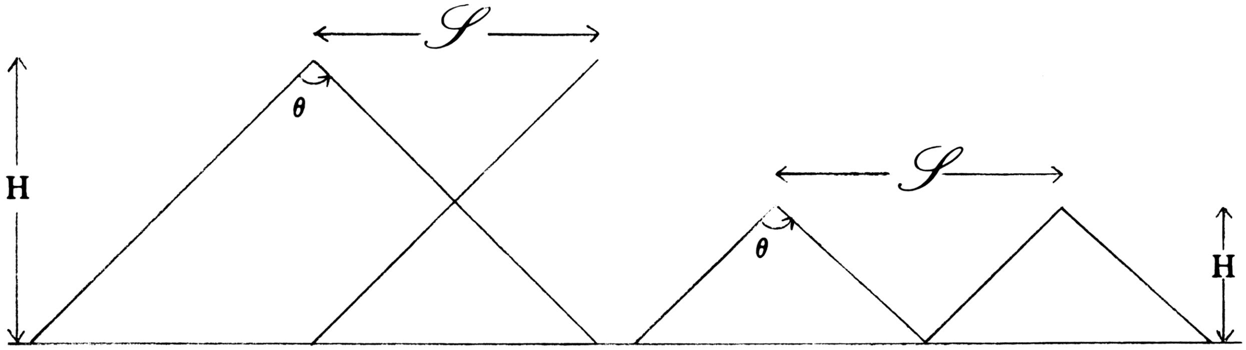
Boom Height

The keystrokes in this section will help you determine the proper nozzle height to achieve either a double overlapping or a single spray pattern. A scientific calculator will be needed for this one.



The first information we will need is the spray angle of the nozzle. Flat fan nozzles are labeled with a four digit code. The first two digits represent the spray angle in degrees, and the last two digits represent the rate of flow in tenths of a gallon per minute at a pressure of 40 psi. The letter E on the end means that the spray is evenly distributed over the width. We will call the spray angle θ (theta).

NOTE: Most scientific calculators can work in radians, degrees, or grads. (2π radians = 360° = 400 grads) Make sure your calculator is set to work in degrees.



In the diagram above, H is the nozzle height, S is the nozzle spacing, and θ is the spray angle. The formula for the overlapping case is:

$$H = \frac{S}{\tan(\theta/2)}$$

Algebraic
1. key in θ (degrees)
2. ÷
3. 2
4. =
5. tan
6. 1/x
7. X
8. key in S (inches)
9. =
   H displayed (inches)

RPN
1. Key in θ (degrees)
2. ENTER
3. 2
4. ÷
5. TAN
6. 1/x
7. key in S (inches)
8. X
   H displayed (inches)

The formula for the single spray pattern is:

$$H = \frac{S}{2\tan(\theta/2)}$$

Algebraic
1. key in θ (degrees)
2. ÷
3. 2
4. =
5. tan
6. X
7. 2
8. =
9. 1/x
10. X
11. key in S (inches)
12. =
    H displayed (inches)

RPN
1. key in θ (degrees)
2. ENTER
3. 2
4. ÷
5. TAN
6. 2
7. X
8. 1/x
9. key in S (inches)
10. X
    H displayed (inches)

Sprayer Calibration—Adjusting Concentration

We will first need the following information:

AI = desired pounds of active ingredient per acre
NS = nozzle spacing (inches)

SS = sprayer speed (mph)
NR = nozzle rate (ounces/min)

The nozzle rate can be found by catching and measuring the solution from one nozzle for one minute. If your cylinder is graduated in milliliters, just multiply the number of milliliters you catch by 0.0338 to get fluid ounces (see Ch 3).

We will first find the desired concentration of the spray solution (i.e. the pounds of active ingredient per gallon of solution).

NOTE: The keystroke sequence that follows will work for other inputs. For example, if you use pints of concentrate per acre instead of AI, the sequence will give pints of concentrate per gallon of solution.

To find the volume of solution sprayed per unit area, we can find the volume of solution sprayed per unit time and then divide this by the area covered per unit time.

$$\frac{\text{Vol. Soln.}}{\text{Area}} = \frac{(NN)(NR)}{(NS)(NN)(SS)}$$

$$= \frac{NR}{(NS)(SS)}$$

Since we want the answer to be in gallons per acre, we will make some unit conversions.

$$\frac{\text{Vol Soln}}{\text{Area}} = \frac{NR(\text{fl oz/min})(60\text{ min/hr})(.00782\text{ gal/fl oz})}{NS(\text{in})(1\text{ ft}/12\text{ in})SS(\text{mi/hr})(5280\text{ ft/mi})(1\text{ Acre}/43560\text{ sqft})}$$

$$= \frac{NR}{(NS)(SS)}\ (46.45)\ \text{gal/acre}$$

We can now divide the pounds of active ingredient per acre by the gallons of solution per acre to get the desired concentration in pounds of active ingredient per gallon of solution.

$$\text{Concentration} = \frac{(AI)(NS)(SS)(46.45)}{NR}\ \text{pounds/gallon}$$

<u>Algebraic</u>

1. key in NR (fl. oz./min.)
2. ÷
3. key in NS (in.)
4. ÷
5. key in SS (mph)
6. X
7. 46.45
8. =
   gal./acre displayed
9. 1/x
10. X
11. key in AI (lb./acre)
12. =
    concentration disp. (lb./gal.)

<u>RPN</u>

1. key in NR (fl. oz./min.)
2. ENTER
3. key in NS (in.)
4. ÷
5. key in SS (mph)
6. ÷
7. 46.45
8. X
   gal./acre displayed
9. 1/x
10. key in AI (lb./acre)
11. X
    concentration disp. (lb./gal.)

Sprayer Calibration--Adjusting Pressure

Suppose we have to haul water a long distance to the field, and we want to use the maximum recommended concentration. Choosing a specific concentration, we can calibrate the sprayer by adjusting the pressure. Since the rate of flow from the nozzle is approximately proportional to the square root of the pressure, we can use a simple curve fitting technique to find the desired pressure. The pressure gauge need not be calibrated.

Beginning with the maximum recommended concentration in pounds of active ingredient per gallon of solution, we can find the desired nozzle rate in ounces per minute.

$$NR(\text{fl oz/min}) = \frac{AI\left(\frac{\text{lb.}}{\text{acre}}\right)\left(\frac{1\ \text{acre}}{43560\ \text{ft.}^2}\right) NS(\text{in.})\left(\frac{1\ \text{ft.}}{12\ \text{in.}}\right) SS\left(\frac{\text{mi.}}{\text{hr.}}\right)\left(\frac{5280\ \text{ft.}}{\text{mi}}\right)\left(\frac{1\ \text{hr.}}{60\ \text{min}}\right)}{\text{Concentration}\left(\frac{\text{lb.}}{\text{gal.}}\right)\left(\frac{.00728\ \text{gal.}}{\text{fl. oz.}}\right)}$$

$$= \frac{(AI)(NS)(SS)(.02153)}{\text{Concentration}} \ \frac{\text{fl. oz.}}{\text{min.}}$$

Now we pick a convenient pressure, say 40 psi on the gauge and then catch and measure the nozzle rate at that pressure. Then the desired pressure can be found from:

$$\text{desired pres.} = \left[\frac{\text{desired NR}}{\text{measured NR}}\sqrt{\text{measured pres.}}\right]^2$$

Algebraic

1. key in AI (lb./acre)
2. X
3. key in NS (in.)
4. X
5. key in SS (mph)
6. X
7. .02153
8. ÷
9. key in conc. (lb./gal.)
10. =
    desired NR disp. (fl oz/min)
11. ÷
12. key in measured NR (fl oz/min)
13. X
14. key in measured pres. (psi)
15. $\sqrt{x}$
16. =
17. x^2
    desired pres. displayed (psi)

RPN

1. key in AI (lb./acre)
2. ENTER
3. key in NS (in.)
4. X
5. key in SS (mph)
6. X
7. .02153
8. X
9. key in conc. (lb./gal.)
10. ÷
    desired NR disp. (fl oz/min)
11. key in measured NR (fl oz/min)
12. ÷
13. key in measured pres. (psi)
14. $\sqrt{x}$
15. X
16. x^2
    desired pres. displayed (psi)

After adjusting the pressure, check to be sure you have the desired NR.

Chapter 5

ACREAGE CALCULATIONS

Introduction

Suppose we have a certain corn acreage to plant. We begin planting in one field, but when we get to the wet side of the field, the planter starts gumming up and we have to quit. It's getting late in the season, and we decide to go to another field to plant the remainder of the corn acreage. We need to know how many acres we planted in the first field, and then how far to plant in the alternate field.

The problems in this chapter will use measurements from standard aerial photographs. It may seem strange to take measurements from a map which is not printed to any particular scale, but the scale will be determined by the total acreage in a field. Of course, the accuracy and precision of the results are both limited by the measurements. We will work in units of 1/32 inch for map measurements, inches for row width, feet for distances in the field, and acres.

NOTE: Although the keystrokes and programs in this chapter call for map measurements in units of 1/32 inch, they will actually work for any units you want to use as long as you are consistent throughout. For example, you could substitute millimeters whenever 1/32 inch measurements are called for as long as you make all your measurements in millimeters. Of course, measurements in millimeters would be less precise. If you want to be more precise, you could use 1/64 inch units. But be careful to count correctly, or what you gain in precision you could more than lose in accuracy.

We will first treat a simple geometry and then consider fields with arbitrarily shaped boundaries.

NOTE: For the first two sections, "length" will refer to a distance in the direction of the rows, and "width" will refer to a distance in the direction perpendicular to the rows.

Rectangular: Acres Covered

Algebraic

1. key in width (1/32 in.)
2. X
3. key in length (1/32 in.)
4. =
5. STO or x→M
6. key in length again (1/32 in.)
7. X
8. key in dist. planted (1/32 in.)
9. ÷
10. RCL or RM
11. X
12. key in acres in field
13. =

acres planted displayed

RPN

1. key in width (1/32 in.)
2. ENTER
3. key in length (1/32 in.)
4. X
5. LASTX
6. key in dist. planted (1/32 in.)
7. X
8. ÷
9. 1/x
10. key in acres in field
11. X

acres planted displayed

Rectangular: How Far

Algebraic

1. key in acres to plant
2. ÷
3. key in acres in field
4. X
5. key in width (1/32 in.)
6. =

dist. to plant disp. (1/32 in.)

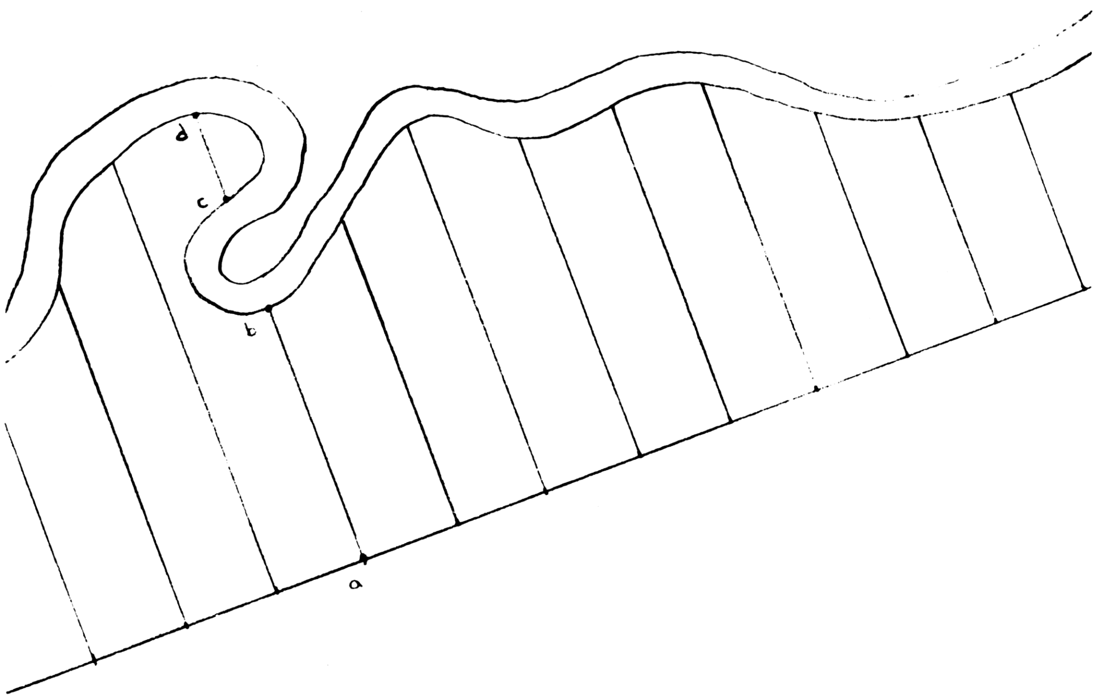
RPN

1. key in acres to plant
2. ENTER
3. key in acres in field
4. ÷
5. key in width (1/32 in.)
6. X

dist. to plant disp. (1/32 in.)

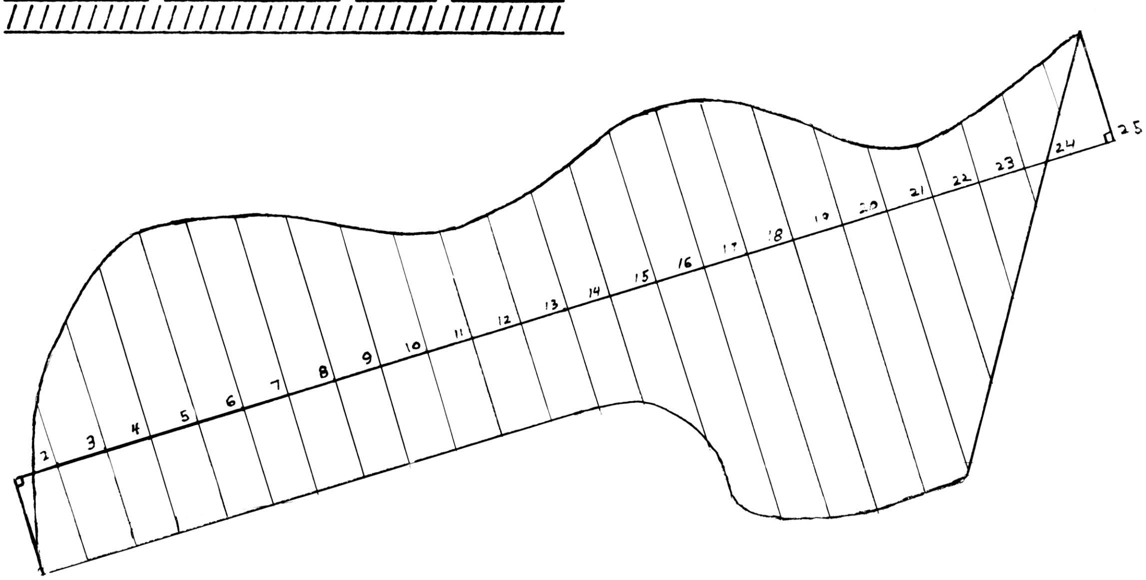
Dealing with Convolutions

The last sections in this chapter are based on drawing lines on a map, dividing these lines into segments, and making measurements from the lines to the field boundaries. The calculations will use a trapezoidal area approximation. We could encounter a peculiarity when making measurements from the lines to the field boundaries if a boundary has a convolution or fold as along a meandering creek.



As you can see from the diagram above, as we make the fourth measurement from the left, we have to go across a fold in the creek. In this case we simply use the sum of the two segments (from a to b and from c to d).

Arbitrary Boundaries: Acres Covered



(1) Begin by drawing a line on the map which represents the last row planted.

(2) Extend the line such that a perpendicular can be drawn from the line to every point in the field.

(3) Measure the total length of this line and divide the line into a convenient number of segments. You can make hatch marks on the line to indicate the segments.

(4) Now measure the perpendicular distance from the line to the field boundary at each mark (or where the line is extended, from boundary to boundary). It might be convenient to number the marks.

(5) Make tables of the distances as below.

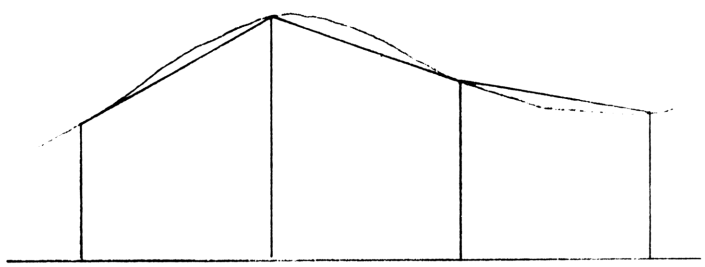
PLANTED AREA MEASUREMENTS (1/32 in)

1.	0.0	14.	18.0
2.	16.5	15.	26.0
3.	16.5	16.	43.0
4.	16.5	17.	45.0
5.	16.5	18.	48.0
6.	16.5	19.	48.0
7.	16.5	20.	48.0
8.	16.5	21.	34.0
9.	16.5	22.	23.0
10.	16.5	23.	6.0
11.	16.5	24.	0.0
12.	16.5	25.	0.0
13.	16.5		

UNPLANTED AREA MEASUREMENTS

1.	0.0	14.	23.5
2.	9.0	15.	26.5
3.	24.5	16.	28.0
4.	29.0	17.	27.0
5.	32.0	18.	23.0
6.	32.0	19.	16.0
7.	31.0	20.	11.0
8.	28.5	21.	9.5
9.	24.0	22.	10.0
10.	21.0	23.	13.0
11.	19.0	24.	9.5
12.	19.0	25.	0.0
13.	21.0		

In this example there are 24 segments on the line and 25 distances in each direction. Also, the width of each segment or "step length" is a constant 8/32 inch, but the step length need not be constant. From points 2 to 13 on the planted side we could have increased the step length without affecting the accuracy of the calculations. Wherever the distances are changing rapidly, the accuracy can be improved by decreasing the step length. But it is usually less confusing to keep a constant step length.



(6) As in the diagram above, we will use the areas of trapezoids as approximations. For each segment, calculate the area on the planted side with the following keystrokes.

Algebraic
1. key in first dist. (1/32 in.)
2. +
3. key in second dist. (1/32 in.)
4. =
5. ÷
6. 2
7. X
8. key in step length (1/32 in.)
9. =
   area displayed $(1/32 \text{ in.})^2$

RPN
1. key in first dist. (1/32 in.)
2. ENTER
3. key in second dist. (1/32 in.)
4. +
5. 2
6. ÷
7. key in step length (1/32 in.)
8. X
   area displayed $(1/32 \text{ in.})^2$

(7) Sum these areas. If your calculator has a memory you can press [STO] or [x→M] after the first segment and then press [STO+], [SUM], or [M+] after each subsequent segment. At the end press [RCL] or [RM] to find the total area.

(8) Repeat these area calculations for the unplanted side.

(9) Now we are ready to find the acres planted. Use the following keystrokes.

Algebraic

1. key in unplanted area (1/32 in.)^2
2. +
3. key in planted area (1/32 in.)^2
4. =
5. 1/x
6. X
7. key in planted area again
8. X
9. key in acres in field
10. =

acres planted displayed

RPN

1. key in unplanted area
2. ENTER
3. key in planted area (1/32 in.)^2
4. +
5. LASTX
6. ÷
7. 1/x
8. key in acres in field
9. X

acres planted displayed

Program ACRES, listed below, performs these calculations using a constant step length. (Divide the line into equal segments.) It first asks the user for the total acres in the field, the length of the last row planted line, and the number of segments. It then asks for the measurements individually, going through the planted side first and then the unplanted side.

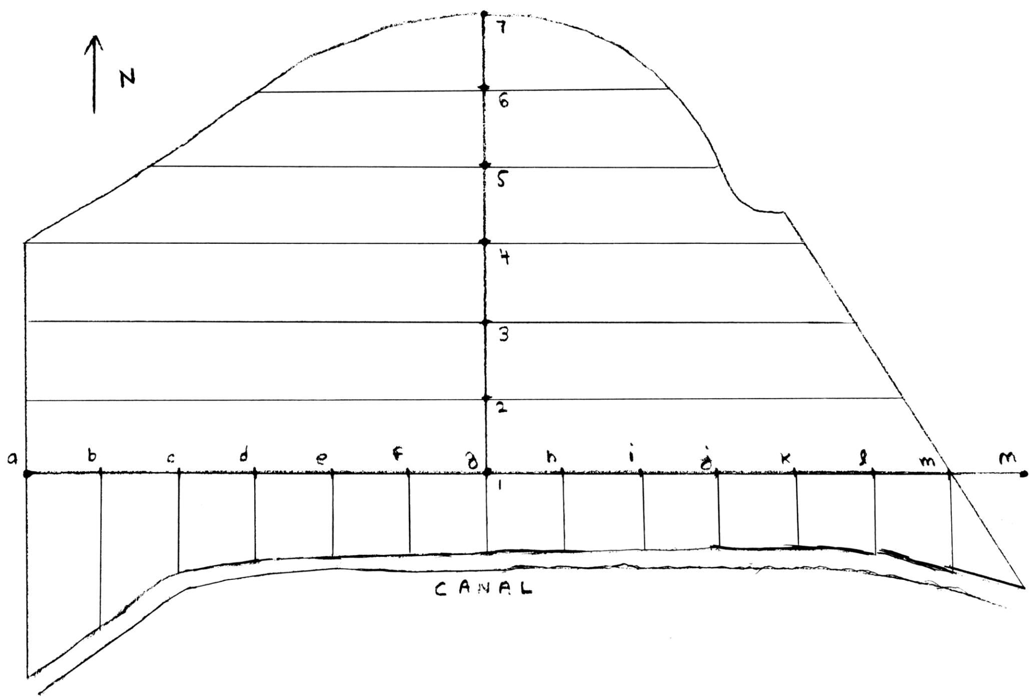
NOTE: To load the ST+ lines, press [STO] then [+] , and then key in the appropriate number.

PROGRAM ACRES (minimum SIZE=009)

```
01  LBL "ACRES"
02  TONE 1
03  "TOTL ACRS=?"
04  PROMPT
05  STO 00
06  TONE 2
07  "LINE LENGTH=?"
08  PROMPT
09  STO 01
10  TONE 3
11  "NO SEGMENTS=?"
12  PROMPT
13  STO 02
14  /
15  STO 03
16  1
17  STO 04
18  0
19  STO 07
20  STO 08
21  TONE 4
22  "FRST PLTD DST=?"
23  PROMPT
24  STO 05
25  LBL 15
26  TONE 4
27  "NEXT DIST=?"
28  PROMPT
29  STO 06
30  RCL 05
31  +
32  2
33  /
34  RCL 03
35  *
36  ST+ 07
37  RCL 06
38  STO 05
39  1
40  ST+ 04
41  RCL 04
42  RCL 02
43  X>Y?
44  GTO 15
45  1
46  STO 04
47  TONE 4
48  "LAST DIST=?"
49  PROMPT
50  RCL 05
51  +
52  2
```

```
53  /
54  RCL 03
55  *
56  ST+ 07
57  TONE 5
58  "FRST UNPL DST=?"
59  PROMPT
60  STO 05
61  LBL 16
62  TONE 5
63  "NEXT DIST=?
64  PROMPT
65  STO 06
66  RCL 05
67  +
68  2
69  /
70  RCL 03
71  *
72  ST+ 08
73  RCL 06
74  STO 05
75  1
76  ST+ 04
77  RCL 04
78  RCL 02
79  X>Y?
80  GTO 16
81  TONE 5
82  "LAST DIST=?"
83  PROMPT
84  RCL 05
85  +
86  2
87  /
88  RCL 03
89  *
90  ST+ 08
91  RCL 07
92  RCL 08
93  +
94  RCL 07
95  X< >Y
96  /
97  RCL 00
98  *
99  STO 01
100 FIX 2
101 BEEP
102 "ACRS PLTD="
103 ARCL 01
104 AVIEW
105 END
```

Arbitrary Boundaries: How Far



Now suppose we want to plant a certain number of acres in a field of arbitrary shape. Referring to the figure above, suppose we pick out landmarks and plant the initial land along a line between points a and n (rows running E-W). After we have planted to the canal, we go back to the other side of the land and we want to know how far to plant to the North. We might be interested in how far on the map in 1/32 in., how far in the field in ft., or how many rows.

This problem is much easier to do with a programmable calculator, but we will look at some keystrokes first. The procedure is somewhat similar to the previous section, but this time we draw two lines on the map to make measurements from.

(1) Draw a line on the map representing the first land and divide this line into segments as before. Make measurements perpendicular from this line to the first field boundary as we did in the previous section (i.e. to the canal in the example above)

(2) Now draw a line perpendicular to the first land line in the other direction. Place this line such that it is the longest perpendicular to the first land line (i.e. so that it reaches the farthest point in the

field). This is the line from point 1 to point 7 in the example.

(3) Divide this second line into segments, and make measurements perpendicular from this line to the field boundaries. Make a table as below.

N-S	EAST	WEST
a. 32	1. 72	1. 72
b. 23	2. 72	2. 64
c. 16	3. 72	3. 56
d. 14	4. 72	4. 50
e. 13	5. 54	5. 36
f. 13	6. 35	6. 28
g. 13		
h. 13		
i. 13		
j. 12		
k. 12		
l. 14		
m. 16		
n. 0		

(4) We will use a trapezoidal approximation as before. Follow the keystrokes listed in the previous section. This time make a table of areas as below.

N-S			EAST	WEST	E + W
a-b.	330	1-2.	864	816	1680
b-c.	234	2-3.	864	720	1584
c-d.	180	3-4.	864	636	1500
d-e.	162	4-5.	756	516	1272
e-f.	156	5-6.	534	384	918
f-g.	156	6-7.	210	168	378
g-h.	156				7332
h-i.	156				
i-j.	150				
j-k.	144				
k-l.	156				
l-m.	180				
m-n.	96				
	2256				

Total = 9588 $(1/32 \text{ in.})^2$

(5) Find the total area in $(1/32 \text{ in.})^2$.

(6) We can now determine the scale of the map from the total acres in the field.

$$\sqrt{\frac{(\text{Acres})(43560\ \text{ft.}^2/\text{Acre})}{\text{Area}\ (1/32\ \text{in.})^2}} = \frac{\text{ft.}}{1/32\ \text{in.}}$$

Algebraic

1. key in total acres
2. ÷
3. key in total area $(1/32\ \text{in.})^2$
4. =
   scale [acres per $(1/32\ \text{in})^2$] disp.
5. X
6. 43560
7. =
8. $\sqrt{x}$
   scale (ft. per 1/32 in.) disp.
9. X
10. 12
11. =
    scale (in. per 1/32 in.) disp.
12. ÷
13. key in row spacing (in.)
14. =
    scale (rows per 1/32 in.) disp.

RPN

1. key in total acres
2. ENTER
3. key in total area $(1/32\ \text{in.})^2$
4. ÷
   scale [acres per $(1/32\ \text{in})^2$] disp.
5. 43560
6. X
7. $\sqrt{x}$
   scale (ft. per 1/32 in.) disp.
8. 12
9. X
   scale (in. per 1/32 in.) disp.
10. key in row spacing (in.)
11. ÷
    scale (rows per 1/32 in.) disp.

(7) How we proceed from this point depends on what kind of information we want. In any case, we will make a graph of acres vs. distance along the second line we drew. For our example we will first sum the N-S areas and multiply by the acres per $(1/32\ \text{in.})^2$. This gives us the acres in the first part we planted. For our example, suppose there are a total of 35 acres in the field, and we want to plant a total of 25 acres with 30 inch rows. Using the keystrokes, we find:

.00365 acres per $(1/32\ \text{in.})^2$

12.61 ft. per 1/32 in.

151.32 in. per 1/32 in.

5.04 rows per 1/32 in.

8.24 acres in the first part

For each segment on the second line, we will again multiply by the acres per $(1/32\ \text{in.})^2$, but this time we will also find the cumulative acres as we go along the line. Don't forget to add the acres we planted first. For our example, the table would look like the one below:

	1/32 in.	(1/32 in)^2	ACRES	CUMULATIVE ACRES
				8.24
1-2.	12	1680	6.13	14.37
2-3.	24	1584	5.78	20.15
3-4.	36	1500	5.48	25.63
4-5.	48	1272	4.64	30.27
5-6.	60	918	3.35	33.62
6-7.	72	378	1.38	35.00

We plot the points and draw a smooth curve through them. (See the graph on the next page.) We could have plotted cumulative acres vs. rows or distance in the field in ft. instead, but we can also convert the values from this graph.

$$(34.6/32 \text{ in.})\left(\frac{5.04 \text{ rows}}{1/32 \text{ in.}}\right) = 174.38 \text{ rows}$$

or,

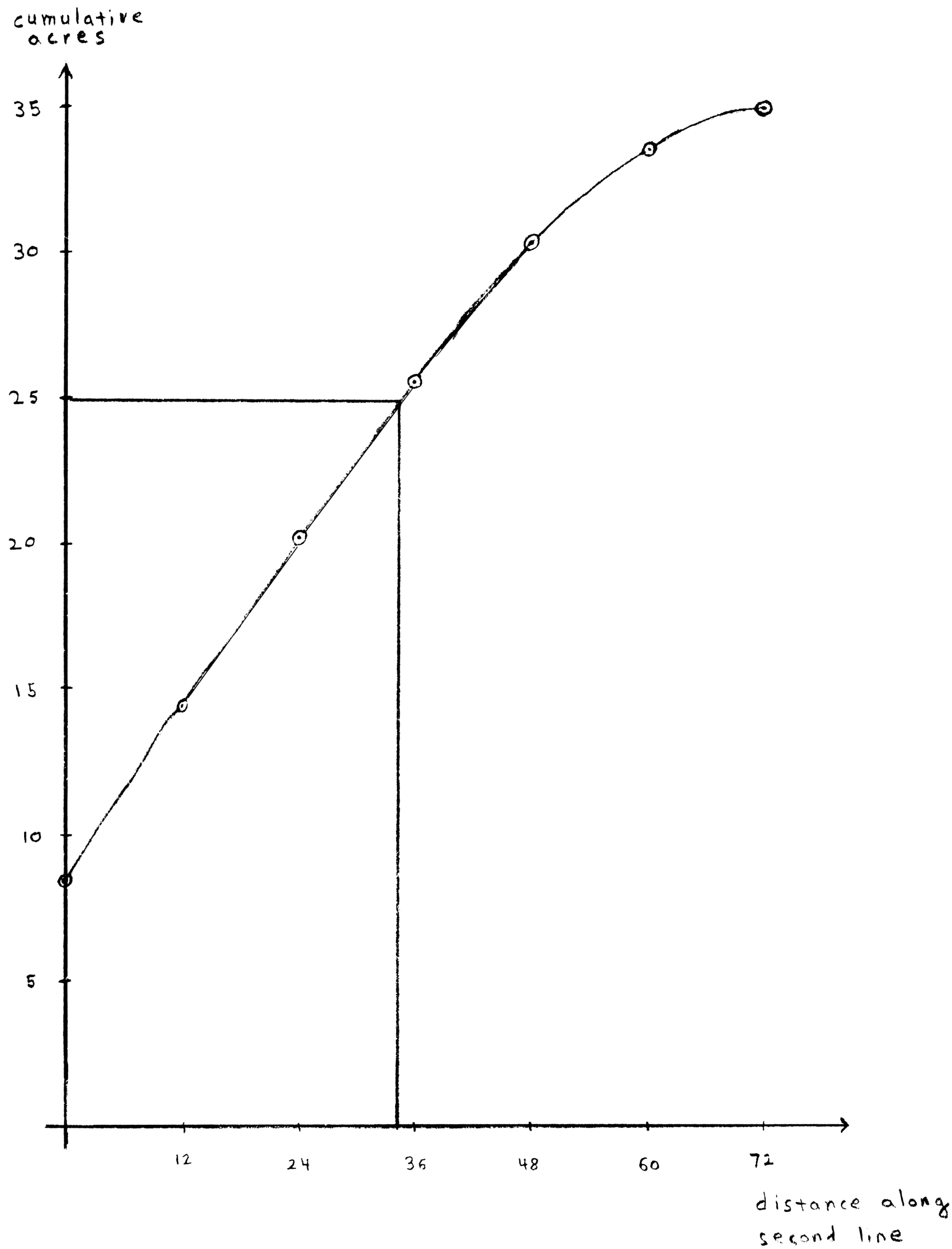
$$(34.6/32 \text{ in.})\left(\frac{12.61 \text{ ft.}}{1/32 \text{ in.}}\right) = 436.31 \text{ ft.}$$

Program HOWFAR, listed below, performs these calculations using constant step lengths for both lines. The number of segments for the second line will be 6, but the number of segments for the first line can be varied. (i.e. Divide the first line into any number of equal segments, and divide the second line into 6 equal segments.)

NOTE: To load the RCL IND steps, first press RCL, then press the shift key, and then key in the appropriate number. (This is called "indirect addressing".)

NOTE: After storing some preliminary information, the program asks for the distances from the first line, then the distances from the second line in one direction, and then the distances from the second line in the other direction. The aural tones should help you keep track of where you are.

NOTE: In case you forget, the output tells you how far to plant after you go back to the other side of the initial land. In out example, we planted the initial land from point a toward point n. Then we worked toward the canal. After we planted to the canal, we went back to the other side of the first rows and started working our way to the North (rows running E-W). Program HOWFAR tells us how far to the North to plant from the initial rows. Of course, all this assumes that the area we planted toward the canal was less than the total acres we want to plant in the field.


cumulative acres
35
30
25
20
15
10
5
12
24
36
48
60
72
distance along second line

IMPORTANT: Maybe you're tired of reading notes by now, but this one is important. This program doesn't access the last segment on the second line. In our example, if we wanted to plant more than 33.5 acres in the 35 acre field, then the program wouldn't work. Incrementing of the distance to plant stops when we reach the last segment. If you want to plant nearly all of the field, then use the graph method or try moving the initial land to make the segments shorter.

PROGRAM HOWFAR (minimum SIZE=036)

```
01 LBL "HOWFAR"
02 TONE 1
03 "TOTL ACRS=?"
04 PROMPT
05 STO 00
06 TONE 2
07 "LINE 1 LENGTH=?"
08 PROMPT
09 STO 01
10 TONE 3
11 "NO SEGMENTS=?"
12 PROMPT
13 STO 02
14 /
15 STO 03
16 TONE 4
17 "LINE 2 LENGTH=?"
18 PROMPT
19 STO 04
20 6
21 /
22 STO 05
23 0
24 STO 09
25 STO 10
26 1
27 STO 06
28 TONE 5
29 "FIRST DIST=?"
30 PROMPT
31 STO 07
32 LBL 25
33 TONE 5
34 "NEXT DIST=?"
35 PROMPT
36 STO 08
37 RCL 07
38 +
39 2
40 /
41 RCL 03
42 *
43 ST+ 09
44 RCL 08
45 STO 07
46 1
47 ST+ 06
48 RCL 06
49 RCL 02
50 X>Y?
51 GTO 25
52 TONE 5
53 "LAST DIST=?"
54 PROMPT
55 RCL 07
56 +
57 2
58 /
59 RCL 03
60 *
61 ST+ 09
62 TONE 6
63 "DIST 1-1=?"
64 PROMPT
65 STO 11
66 TONE 6
67 "DIST 2-1=?"
68 PROMPT
69 STO 12
70 TONE 6
71 "DIST 3-1=?"
72 PROMPT
73 STO 13
74 TONE 6
75 "DIST 4-1=?"
76 PROMPT
77 STO 14
78 TONE 6
79 "DIST 5-1=?"
80 PROMPT
81 STO 15
82 TONE 6
83 "DIST 6-1=?"
84 PROMPT
85 STO 16
86 TONE 7
```

```
87  "DIST 1-2=?"
88  PROMPT
89  STO 17
90  TONE 7
91  "DIST 2-2=?"
92  PROMPT
93  STO 18
94  TONE 7
95  "DIST 3-2=?"
96  PROMPT
97  STO 19
98  TONE 7
99  "DIST 4-2=?"
100 PROMPT
101 STO 20
102 TONE 7
103 "DIST 5-2=?"
104 PROMPT
105 STO 21
106 TONE 7
107 "DIST 6-2=?"
108 PROMPT
109 STO 22
110 TONE 8
111 "ROW SPACING=?"
112 PROMPT
113 STO 23
114 TONE 9
115 "ACRS TO PLANT=?"
116 PROMPT
117 STO 26
118 0
119 STO 06
120 11
121 STO 24
122 12
123 STO 25
124 LBL 26
125 RCL IND 24
126 RCL IND 25
127 +
128 2
129 /
130 RCL 05
131 *
132 ST+ 10
133 STO IND 24
134 1
135 ST+ 06
136 ST+ 24
137 ST+ 25
138 4
139 RCL 06
140 X≤Y?
141 GTO 26
142 RCL 16
143 2
144 /
145 RCL 05
146 *
147 ST+ 10
148 STO 16
149 0
150 STO 06
151 17
152 STO 24
153 18
154 STO 25
155 LBL 27
156 RCL IND 24
157 RCL IND 25
158 +
159 2
160 /
161 RCL 05
162 *
163 ST+ 10
164 STO IND 24
165 1
166 ST+ 06
167 ST+ 24
168 ST+ 25
169 4
170 RCL 06
171 X≤Y?
172 GTO 27
173 RCL 22
174 2
175 /
176 RCL 05
177 *
178 ST+ 10
179 STO 22
180 RCL 09
181 RCL 10
182 +
183 1/X
184 RCL 00
185 *
186 STO 29
187 43560
188 *
189 SQRT
190 STO 27
191 12
192 *
193 RCL 23
194 /
```

```
STO 28
RCL 09
RCL 29
*
STO 30
CHS
RCL 26
+
STO 31
11
STO 24
LBL 28
RCL 29
ST* IND 24
1
ST+ 24
21
RCL 24
X≤Y?
GTO 28
0
STO 32
STO 33
11
STO 24
17
STO 25
LBL 29
RCL 33
STO 35
RCL 05
ST+ 33
RCL 32
STO 34
RCL IND 24
RCL IND 25
+
ST+ 32
1
ST+ 24
ST+ 25
RCL 32
RCL 31
X>Y?
GTO 29
RCL 33
RCL 35
-
RCL 32
RCL 34
-
/
RCL 32
RCL 31
-
*
RCL 33
-
CHS
STO 06
RCL 27
*
STO 07
RCL 06
RCL 28
*
STO 08
FIX 2
BEEP
"DST 1/32IN="
ARCL 06
AVIEW
STOP
BEEP
"DIST FT="
ARCL 07
AVIEW
STOP
BEEP
"ROWS TO PLT="
ARCL 08
AVIEW
END
```

Chapter 6

PEST SCOUTING CALCULATIONS

Counting

The sequence in this section calculates the number per row foot and number per acre from the count, row feet scouted, and row spacing.

Algebraic

1. key in no. pests counted
2. ÷
3. key in row ft. scouted
4. =
   no./row ft. displayed
5. ÷
6. key in row spacing (in.)
7. X
8. 522,720
9. =
   no./acre displayed

RPN

1. key in no. pests counted
2. ENTER
3. key in row ft. scouted
4. ÷
   no./row ft. displayed
5. key in row spacing (in.)
6. ÷
7. 522,720
8. X
   no./acre displayed

Simple Population Growth

The sequence in this section enables the user to predict a future insect or mite population when the population growth is not complicated by factors such as emigration, immigration, predators, etc. A scientific calculator will be required.

Suppose we scout a field at time t=0 and find N_o pests per acre. If the population growth is uninhibited, then at any time, t, after t=0, the population will be

$$N = N_o e^{rt}$$

where the rate, r, can be determined by scouting at some arbitrary time after t=0. We will call this time t_1 and the population found at this second scouting N_1.

at $t = 0$, $N = N_0$

at $t = t_1$, $N = N_1$

Therefore,

$$N_1 = N_0 e^{rt_1}$$

or,

$$r = \frac{\ln N_1 - \ln N_0}{t_1}$$

So we need the first population, N_0. This is at time $t=0$. At some later time, t_1, we scout again and find the population N_1. This will enable us to predict the population, N, at any other time, t.

NOTE: t_1 and t can be in hours, days, or any other convenient unit of time as long as they are in the same units.

Algebraic

1. key in N_0
2. STO or x→M
3. ln
4. +/−
5. +
6. key in N_1
7. ln
8. =
9. ÷
10. key in t_1
11. X
12. key in t
13. =
14. e^x
15. X
16. RCL or RM
17. =

    N displayed

RPN

1. key in N_0
2. ENTER
3. LN
4. CHS
5. key in N_1
6. LN
7. +
8. key in t_1
9. ÷
10. key in t
11. X
12. e^x
13. X

    N displayed

Program SIMPG (min SIZE=1)

```
LBL "SIMPG"
TONE 1
"NO=?"
PROMPT
STO 00
LN
CHS
TONE 2
"N1=?"
PROMPT
LN
+
TONE 3
"T1=?"
PROMPT
/
TONE 4
"DESIRED T=?"
PROMPT
*
e^x
RCL 00
*
STO 00
FIX 2
BEEP
"PREDICTED N="
ARCL 00
AVIEW
END
```

Chapter 7

CABLE TENSION

Introduction

The keystrokes in this chapter will aid the user in determining whether the maximum tension rating of a cable or chain is sufficient for a particular pull-out operation. They will help the operator of the pulling tractor to choose an appropriate gear. While the first two sections deal with static tension, the last section will demonstrate the effects of jerking the cable.

The numerical results should not be construed as a guarantee that a cable or chain will not break under given circumstances. A good safety margin should always be included, especially when using a worn or damaged cable or a patched chain. And, of course, ALWAYS BE SURE EVERYBODY IS A SAFE DISTANCE FROM THE CABLE BEFORE TENSIONING.

Maximum Static Tension—Parallel Pull

Drawbar horsepower and groundspeed for a particular gear and engine speed can generally be ascertained from a tractor operator's manual and/or plackards. Given these parameters, it is an easy matter to determine the corresponding force and hence, the corresponding cable tension. The general formula is

$$\text{Force} = \frac{\text{Power}}{\text{Speed}}$$

provided the force and speed are in the same direction. We will probably have the power in hp and the speed in mph. To find the tension in pounds, we will need a conversion factor:

$$\text{Tension} = \frac{\text{Power (hp)(33,000 ft.-lb./min.-hp)}}{\text{Speed (mi./hr.)(1 hr./60 min.)(5280 ft./mi.)}}$$

$$= \frac{375(\text{Power})}{\text{Speed}} \quad \text{lb.}$$

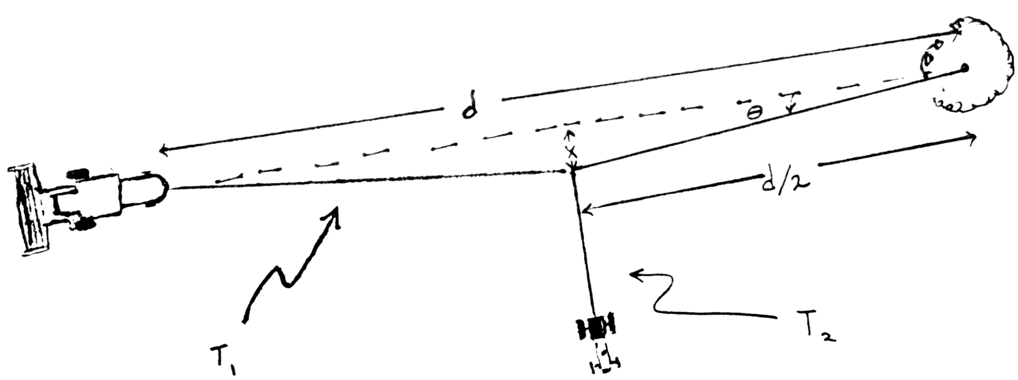
Algebraic
1. key in power (hp)
2. ÷
3. key in speed (mph)
4. X
5. 375
6. =
   tension displayed (lb.)

RPN
1. key in power (hp)
2. ENTER
3. key in speed (mph)
4. ÷
5. 375
6. X
   tension displayed (lb.)

Keep in mind that this assumes no spinning and no jerking. Spinning will reduce the tension from the calculated value, and jerking will momentarily increase the tension. By "static" we mean under a constant load.

Maximum Static Tension—Perpendicular Pull

If you happen to have something heavy or solid to anchor to (for instance, a convenient tree) and a cable or chain long enough to reach it, you can achieve a tremendous tension by applying a much smaller tension to a second, smaller cable or chain. A scientific calculator will be needed for this one.



The distance x can be varied by adjusting the slack in the main cable (T_1), and the distances d and x will determine the relationship between T_2 and T_1. Of course, x will increase as the cable stretches or the stuck machine begins to move.

From the figure,

$$\frac{x}{d/2} = \tan\theta$$

In equilibrium, both the tree and the stuck machine will exert a force component opposite in direction to T_2 of magnitude $T_1 \sin\theta$, so

$$T_2 = 2T_1 \sin\theta$$

Hence,

$$T_1 = \frac{T_2}{2\sin\theta} = \frac{T_2}{2\sin\left[\arctan(2x/d)\right]}$$

T_2 can be found with the keystrokes listed in the previous section, and then all we need to know is x and d in ft. (Actually, as long as x and d are measured in the same units, they could be in any units of length.)

NOTE: For this problem, the calculator must be set up to work in <u>radians</u> instead of degrees. Some calculators without continuous memory will "wake up" with the angular mode in degrees, so you will have to shift to radians. Check the owner's manual.

Algebraic	RPN
1. shift the angular mode to radians....................	
2. key in x (ft.)	2. key in x (ft.)
3. ÷	3. ENTER
4. key in d (ft.)	4. key in d (ft.)
5. X	5. ÷
6. 2	6. 2
7. =	7. X
8. $\tan^{-1}$	8. TAN^{-1}
9. sin	9. SIN
10. X	10. 2
11. 2	11. X
12. =	12. 1/x
13. 1/x	13. key in T_2 (lbs.)
14. X	14. X
15. key in T_2 (lbs.)	T_1 displayed (lbs.)
16. =	
T_1 displayed (lbs.)	

Tension with an Impulsive Load

This section is primarily for demonstration purposes since the time interval over which an impulsive load is delivered to a cable or chain is hard to estimate. Chains don't stretch much, so with a chain, the interval is very short. Generally, the longer the chain or cable, the longer the interval. The peak load is less for longer intervals.

Suppose one end of your cable is attached to a very heavy machine. With the cable initially slack, the pulling tractor accelerates to a certain speed and then "coasts" into the cable. Suppose further that the stuck machine is heavy enough and stuck enough to stop the pulling tractor without moving appreciably itself. After accelerating, the pulling tractor has "momentum". The magnitude of the momentum depends on the tractor's weight and speed. As the cable tightens, and the tractor is stopped, the tractor's momentum decreases to zero. In the process of stopping, the tractor has delivered an "impulse" to the cable which is equal in magnitude to its change in momentum.

$$\text{momentum} = (\text{mass})(\text{speed})$$

where

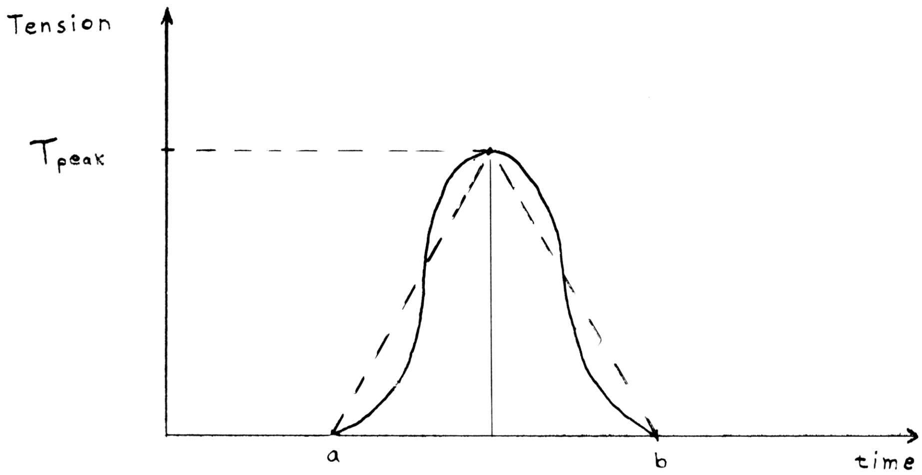
$$\text{mass} = \frac{\text{weight}}{\text{acceleration of gravity}}$$

The acceleration of gravity is 32.2 ft./sec.^{2} . We can now find the impulse.

$$\text{impulse} = \frac{\text{weight (lbs.) speed (mi./hr.)(5280 ft./mi.)(1 hr./3600 sec.)}}{\text{32.2 ft./sec.}^2}$$

$$= .04555\ (\text{weight})(\text{speed})\ \text{lb.-sec.}$$

If we plot the tension as a function of time, the curve will look something like the one in the figure below. The time interval starts at a and ends at b.



For our purposes, the triangular spike function shown with hatched lines will be a good enough approximation to the impulse function. The impulse is equal to the area under the curve which is in turn equal to one half the time interval multiplied by the height of the pulse, and the height of the pulse is just the peak tension. (The peak tension is what we are ultimately interested in.)

$$\text{peak tension} = \frac{2(\text{impulse})}{\text{time interval}}$$

<u>Algebraic</u>
1. key in weight (lbs.)
2. X
3. key in speed (mph)
4. ÷
5. key in time interval (sec)
6. X
7. .0911
8. =
   peak tension displayed (lbs.)

<u>RPN</u>
1. key in weight (lbs.)
2. ENTER
3. key in speed (mph)
4. X
5. key in time interval (sec)
6. ÷
7. .0911
8. X
   peak tension displayed (lbs.)

As an example, suppose you are pulling with a tractor that has a gross weight of 10,000 lbs., and you coast into the cable at 5 mph. If the duration of the impulse is 0.5 sec., then the peak tension would be 9,110 lbs.

Now suppose you were pulling with a short chain instead, and the jerk lasts for only 0.1 sec. The peak tension in this case would be 45,550 lbs. (Something will probably break before the peak tension is reached.)

Chapter 8

VOLUME CALCULATIONS

Introduction

Suppose you buy a nitrogen applicator at an auction. The tank has an external sight tube, but the aluminum strip under the tube is missing. Now you need to scale the sight tube in gallons. The programs in the latter part of this chapter perform scaling calculations for containers of various shapes. Each program goes into a loop after collecting the dimensions of the container. Each time around the loop, the program asks for a depth in inches and then calculates the corresponding bushels or gallons.

But first we will look at some keystrokes which will calculate the total volumes of containers with various shapes. Of course, the volume of a rectangular prism (i.e. a regular shoe box shaped structure) is just the product of its three dimensions. So the capacity of an ordinary corn crib 10 ft. wide, 30 ft. long, and 10 ft. deep is just

$$(10 \text{ ft.})(30 \text{ ft.})(10 \text{ ft.})(.80356 \text{ bu./ft.}^3) = 2410.68 \text{ bu.}$$

(See Chapter 3)

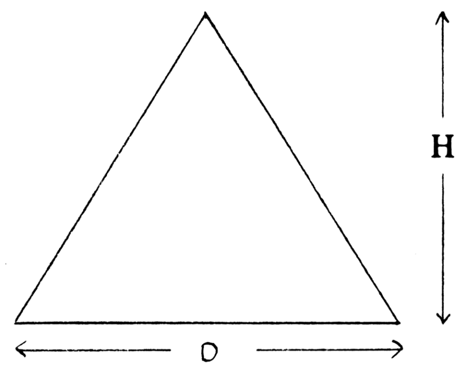
Some of the sequences and programs ask for the diameter as a dimension. If you happen to have the circumference instead, just divide the circumference by π to get the diameter ($\pi = 3.1416$). The radius is just half of the diameter.

Algebraic
1. key in circumference
2. ÷
3. 3.1416
4. =
   diameter displayed
5. ÷
6. 2
7. =
   radius displayed

RPN
1. key in circumference
2. ENTER
3. π
4. ÷
   diameter displayed
5. 2
6. ÷
   radius displayed

NOTE: The "cylinder with spherical end caps" sequences take inputs in inches, but the other total volume sequences are set up to take inputs in various units. If your measurements are in inches, then the volume calculated will be in cubic inches. If your measurements are in feet, then the volume calculated will be in cubic feet. To get from cubic inches or cubic feet, etc. to gallons or bushels, etc., just use the conversion factors in Chapter 3.

Total Volume: Cone



D = diameter of base

H = height

volume = $\pi D^2 H/12$

Algebraic
1. .2618
2. X
3. key in diameter
4. X
5. key in diameter again
6. X
7. key in height
8. =
   volume displayed

RPN
1. .2618
2. ENTER
3. key in diameter
4. x^2
5. X
6. key in height
7. X
   volume displayed

NOTE: In the algebraic sequence, if your calculator has an x^2 key, you can use it in place of steps 4 and 5.

Total Volume: Sphere

D = diameter

volume = $\pi D^3/6$

Algebraic
1. .5236
2. X
3. key in diameter
4. X
5. key in diameter again

RPN
1. key in diameter
2. ENTER
3. 3
4. y^x
5. .5236

6. X
7. key in diameter again
8. =
   volume displayed

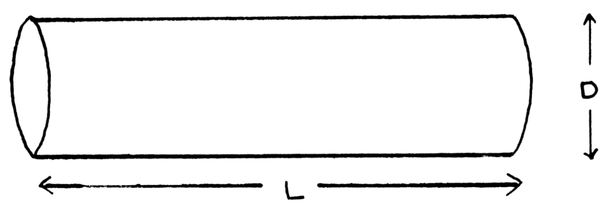
6. X
   volume displayed

Total Volume: Cylinder

D = diameter

L = length (or height)

volume = $\pi D^2 L/4$



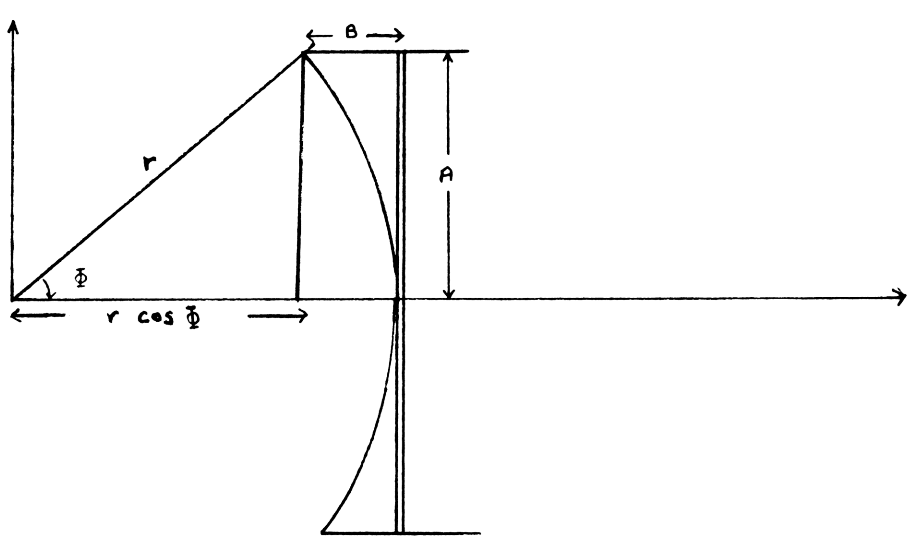
Algebraic
1. .7854
2. X
3. key in diameter
4. X
5. key in diameter again
6. X
7. key in length
8. =
   volume displayed

RPN
1. key in diameter
2. x^2
3. .7854
4. X
5. key in length
6. X
   volume displayed

Total Volume: Cylinder with Spherical End Caps

NOTE: This problem will require a scientific calculator.

The first thing we need to do is to determine the radius of the spherical end caps. We will use a yard stick and two rulers.



From the diagram,

$r - r\cos\Phi = B$ $\qquad$ $r\sin\Phi = A$

$(r - B)^2 = r^2\cos^2\Phi$ $\qquad$ $r^2\cos^2\Phi + A^2 = r^2$

$r^2 - 2rB + B^2 = r^2\cos^2\Phi$ $\qquad$ $r^2\cos^2\Phi = r^2 - A^2$

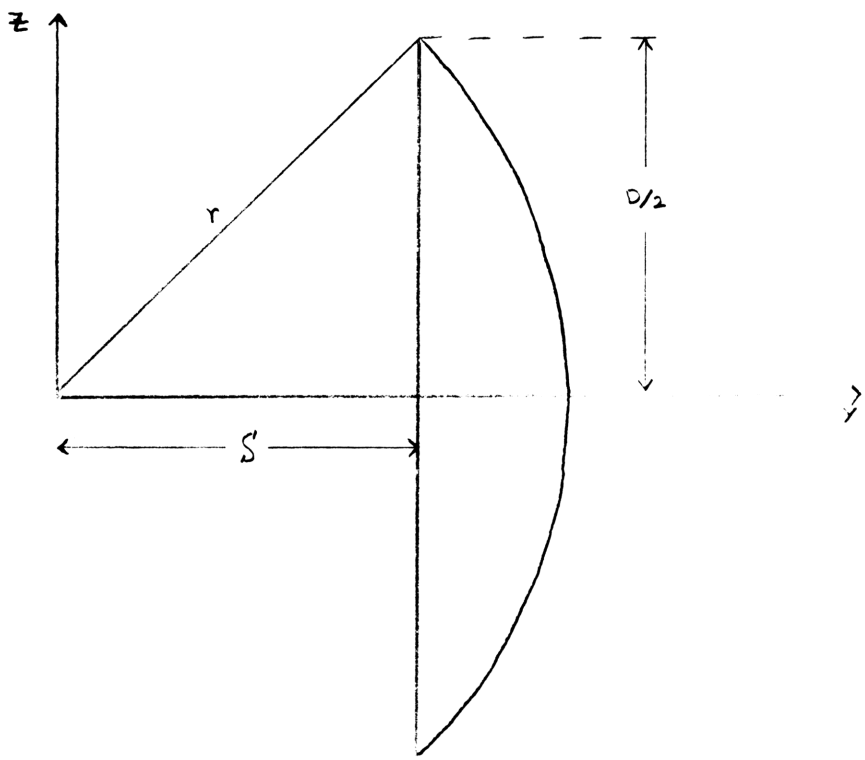
$$r = (A^2 + B^2)/2B$$

Procedure: Place the yardstick such that it is tangent to the spherical surface at its midpoint (i.e. at the 18 inch mark). Place a ruler at each end of and perpendicular to the yardstick. Adjust the yardstick such that it strikes each ruler at the same point and measure on one of the rulers the distance from the spherical surface to the end of the yardstick. This distance is B. The distance A is just 18 inches.

Algebraic
1. key in B (in.)
2. X
3. key in B again (in.)
4. +
5. 324
6. =
7. ÷
8. key in B again (in.)
9. ÷
10. 2
11. =
    r displayed (in.)

RPN
1. key in B (in.)
2. x^2
3. 324
4. +
5. key in B again (in.)
6. ÷
7. 2
8. ÷
    r displayed (in.)

Now that we have r, we can find the volume of a spherical end cap that intersects the cylinder of diameter D.



From the figure,

$$S = \sqrt{r^2 - D^2/4}$$

The sphere intersects the y-z plane in the circle,

$$y^2 + z^2 = r^2$$

We can form the sphere by revolving this circle about the y-axis. We can now use elements of volume in the shape of thin discs perpendicular to the y-axis. The volume of each element is

$$dV_{ec} = \pi z^2 \, dy$$

or,

$$V_{ec} = \int \pi z^2 \, dy = \pi \int_S^r (r^2 - y^2) \, dy$$

$$= \pi \left\{ 2r^3/3 - r^2\sqrt{r^2 - D^2/4} + (1/3)(r^2 - D^2/4)^{3/2} \right\}$$

The total volume is

$$V = \pi D^2 L/4 + 2V_{ec}$$

where L is the length of the cylinder (excluding the end caps).

Algebraic

1. key in D (in.)
2. x^2
3. ÷
4. 4
5. =
6. +/-
7. +
8. key in r (in.)
9. x^2
10. =
11. y^x
12. 1.5
13. =
14. ÷
15. 3
16. =
17. STO or X→M
18. key in D (in.)
19. x^2
20. ÷
21. 4
22. =
23. +/-
24. +
25. key in r (in.)
26. x^2
27. =
28. $\sqrt{x}$
29. X
30. key in r (in.)
31. x^2
32. =
33. +/-
34. SUM or M+
35. key in r (in.)
36. y^x
37. 3
38. =
39. X
40. 2
41. ÷
42. 3
43. =
44. SUM or M+
45. RCL or RM
46. X
47. 2
48. =
49. STO or x→M

RPN

1. key in r (in.)
2. STO 00
3. x^2
4. key in D (in.)
5. STO 01
6. x^2
7. 4
8. ÷
9. −
10. STO 02
11. 1.5
12. y^x
13. 3
14. ÷
15. RCL 02
16. $\sqrt{x}$
17. RCL 00
18. x^2
19. X
20. −
21. RCL 00
22. 3
23. y^x
24. 2
25. X
26. 3
27. ÷
28. +
29. 2
30. X
31. RCL 01
32. x^2
33. key in L (in.)
34. X
35. 4
36. ÷
37. +
38. π
39. X
40. .004329
41. X

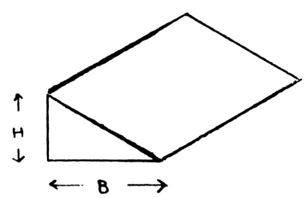
total V (gal.) displayed

50

50. key in D (in.)
51. x^2
52. X
53. key in L (in.)
54. ÷
55. 4
56. =
57. SUM or M+
58. RCL or RM
59. X
60. π
61. =
62. X
63. .004329
64. =
    total V (gal.) displayed

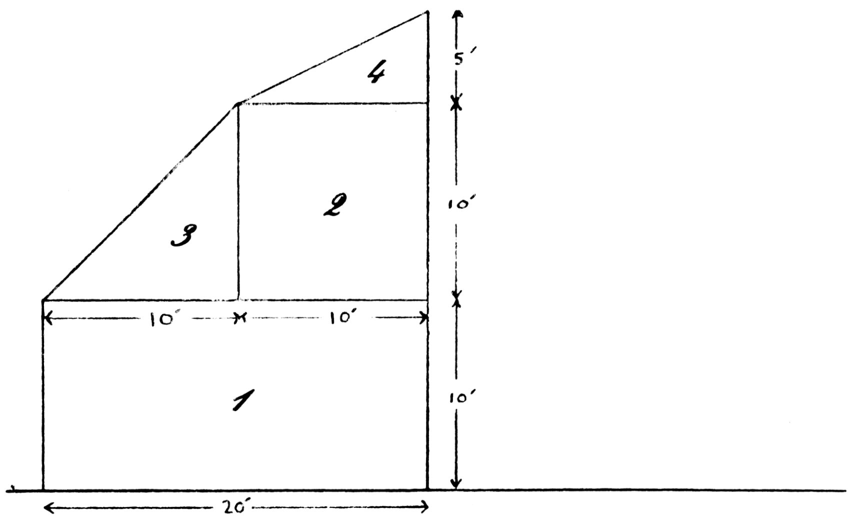
Total Volume: Triangular Sections

V = BHL/2



Algebraic	RPN
1. key in B	1. key in B
2. X	2. ENTER
3. key in H	3. key in H
4. X	4. X
5. key in L	5. key in L
6. ÷	6. X
7. 2	7. 2
8. =	8. ÷
volume displayed	volume displayed

As an example, suppose we want to fill up an old gambrel roof barn with hay. We want to know the number of "square" bales the barn will hold.



The area of one half of the front of the barn is divided into two rectangular sections and two triangular sections in the figure above. We can sum the areas of these sections and multiply by 2 to get the total front area. Multiplying this area by the length will give us the volume.

Area 1 = (20 ft.)(10 ft.) = 200 ft.^{2}

Area 2 = (10 ft.)(10 ft.) = 100 ft.^{2}

Area 3 = (1/2)(10 ft.)(10 ft.) = 50 ft.^{2}

Area 4 = (1/2)(10 ft.)(5 ft.) = 25 ft.^{2}

375 ft.^{2}

2(375 ft.^{2})(50 ft.) = 37,500 ft.^{3}

Suppose our bales are 1.2 ft. X 1.5 ft. X 4 ft. Then each bale has a volume

(1.2 ft.)(1.5 ft.)(4 ft.) = 7.2 ft.^{3}

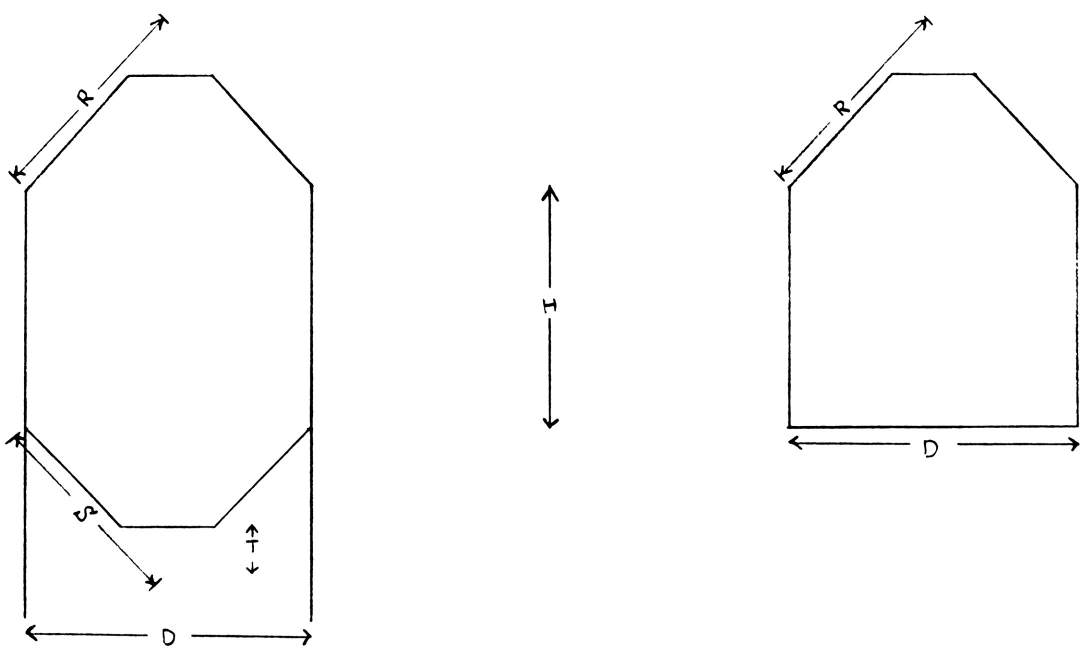
So the barn should hold

$$\frac{37,500 \text{ ft.}^3}{7.2 \text{ ft.}^3} = 5208 \text{ bales}$$

Of course we might be able to store more bales in the barn, because bales on the bottom would be compressed. On the other hand, we wouldn't be able to utilize all of the space in the barn.

Scaling Program: Grain Bins

For this program we will need the five dimensions shown in the diagram below. To measure R, S, and T, extend each conical surface to its apex.



The level will be measured from the bottom of the bin where the lower cone is truncated a distance T above its apex. Measurements will be in inches.

NOTE: This program is designed for hopper bottom bins in general, but it can also be used for ordinary bins. For a regular grain bin, we can just choose T such that we almost completely truncate the lower cone. Pick a value for S (S must be greater than D/2). You may want to pick S to be the same as R, which would be a reasonable value. Now pick T such that

$$T = g - 1 = \sqrt{S^2 - D^2/4} - 1$$

<u>RPN</u>

1. key in D (in.)
2. x^2
3. 4
4. ÷
5. CHS
6. key in S (in.)
7. x^2
8. +
9. SQRT
10. 1
11. −

    T displayed (in.)

(this is the value for T that will almost completely truncate the bottom cone)

Since we have left one inch of the bottom cone, just subtract one inch from H. (If we were to make T exactly equal to g, then inside the calculator, the value stored for T might be a minute amount larger than the value stored for g. In this case, the value T-g would be a very small but still negative number. This would "fool" the calculator as to where the level is in the bin and introduce an error into the calculations.)

NOTE: Each time around the scaling loop, the calculator stops twice (once to ask for the level and then to display the results). Just press [R/S] to continue going around the loop.

<u>Program BIN</u> (minimum SIZE=013)

```
01  LBL "BIN"
02  TONE 1
03  "D INCHES=?"
04  PROMPT
05  STO 00
06  X²
07  4
08  /
09  STO 08
10  CHS
11  TONE 2
12  "R INCHES=?"
13  PROMPT
14  STO 01
15  X²
16  +
17  SQRT
18  STO 06
19  TONE 3
20  "S INCHES=?"
21  PROMPT
22  STO 02
23  X²
24  RCL 08
25  -
26  SQRT
27  STO 05
28  TONE 4
29  "H INCHES=?"
30  PROMPT
31  STO 03
32  TONE 5
33  "T INCHES=?"
34  PROMPT
35  STO 04
36  CHS
37  RCL 05
38  +
```

```
39  STO 09
40  RCL 03
41  +
42  STO 10
43  RCL 06
44  +
45  STO 11
46  LBL 15
47  TONE 6
48  "WHAT LEVEL?"
49  PROMPT
50  STO 07
51  RCL 11
52  X<=Y?
53  GTO 16
54  RCL 07
55  RCL 10
56  X<=Y?
57  GTO 17
58  RCL 07
59  RCL 09
60  X<=Y?
61  GTO 18
62  GTO 19
63  LBL 16
64  "RUNNING OVER"
65  AVIEW
66  BEEP
67  STOP
68  GTO 15
69  LBL 17
70  RCL 11
71  RCL 07
72  -
73  3
74  Y^X
75  RCL 06
76  X^2
77  /
78  12
79  /
80  CHS
81  RCL 06
82  12
83  /
84  +
85  RCL 03
86  4
87  /
88  +
89  RCL 04
90  3
91  Y^X
92  RCL 05
93  X^2
94  /
95  12
96  /
97  -
98  RCL 05
99  12
100 /
101 +
102 RCL 00
103 X^2
104 *
105 PI
106 *
107 .000465
108 *
109 STO 12
110 "BUSHELS="
111 ARCL 12
112 AVIEW
113 BEEP
114 STOP
115 GTO 15
116 LBL 18
117 RCL 09
118 CHS
119 RCL 07
120 +
121 4
122 /
123 RCL 04
124 3
125 Y^X
126 RCL 05
127 X^2
128 /
129 12
130 /
131 -
132 RCL 05
133 12
134 /
135 +
136 RCL 00
137 X^2
138 *
139 PI
140 *
141 .000465
142 *
143 STO 12
144 "BUSHELS="
145 ARCL 12
146 AVIEW
```

```
BEEP
STOP
GTO 15
LBL 19
RCL 07
RCL 04
+
3
Y^X
RCL 04
3
Y^X
-
RCL 00
X^2
*
RCL 05
X^2
/
12
/
PI
*
.000465
*
STO 12
"BUSHELS="
ARCL 12
AVIEW
BEEP
STOP
GTO 15
END
```

Scaling Program: Horizontal Axis Cylinder

The inputs are the diameter, length, and level in inches, and the output is in gallons.

NOTE: Each time around the scaling loop the program stops twice (once to ask for the level and then to display the gallons). Just press R/S to continue going around the loop.

NOTE: Be patient. It takes the calculator a while to do this one.

Program HCLNDR (minimum SIZE=006)

```
LBL "HCLNDR"
TONE 1
"DIA=?"
PROMPT
STO 00
2
/
STO 01
TONE 2
"LENGTH=?"
PROMPT
STO 02
LBL 15
TONE 3
"WHAT LEVEL?"
PROMPT
STO 03
RCL 00
X<>Y
X>Y?
GTO 16
0
STO 04
STO 05
LBL 17
.5
ST+ 05
RCL 01
RCL 05
-
X^2
CHS
RCL 01
X^2
+
SQRT
RCL 02
*
.004329
*
ST+ 04
RCL 05
RCL 03
X>Y?
GTO 17
"GALLONS="
ARCL 04
AVIEW
BEEP
STOP
GTO 15
LBL 16
"RUNNING OVER"
AVIEW
BEEP
STOP
GTO 15
END
```

Scaling Program: Horizontal Cylinder with Spherical End Caps

Inputs will be in inches, and the output will be in gallons. We will first need to find the radius of the spherical end caps. Use the first keystroke sequence in the section on the total volume of a cylinder with spherical end caps. The length is just the length of the cylindrical section (i.e. without the end caps).

NOTE: To load the ACOS line, just press the shift key and then [COS].

NOTE: Each time around the scaling loop the program stops twice (once to ask for the level, and then to display the results). Just press [R/S] to continue going around the loop.

NOTE: Be patient. It takes the calculator a while to do this one.

NOTE: The "level" input corresponds to depth in the tank. If you want to graduate a sight tube along the surface of the end cap, you can convert the program with the following procedure:

(1) Step through the program until you get to line 21.

```
21 STO 04
```

(2) At this point, insert the instruction XEQ "EC".

```
22 XEQ "EC"
```

(The line numbers from here to the end of the program will increase by one.)

(3) Go back to execution mode and press [GTO] [.] [.] to get to the end of program memory.

(4) Go to program mode and load the following subroutine:

<u>Subroutine</u> <u>EC</u>

```
01 LBL EC
02 RCL 04
03 RCL 02
04 /
05 2
06 /
07 SIN
08 RCL 02
09 *
10 2
11 *
12 STO 04
13 END
```

(5) Now you can give the calculator inches along the spherical end cap when it asks for the "level".

<u>Program</u> <u>ENDCAP</u> (minimum SIZE=009)

```
01 LBL "ENDCAP"
02 TONE 1
03 "DIA=?"
04 PROMPT
05 STO 00
06 2
07 /
08 STO 01
09 TONE 2
10 "SPH RDUS=?"
11 PROMPT
12 STO 02
13 TONE 3
14 "LENGTH=?"
15 PROMPT
16 STO 03
17 LBL 15
18 TONE 4
19 "WHAT LEVEL?"
20 PROMPT
21 STO 04
22 RCL 00
23 X<>Y
24 X>Y?
25 GTO 16
26 0
27 STO 05
28 STO 06
29 LBL 17
30 .5
31 ST+ 06
32 RCL 01
33 X^2
34 RCL 01
35 RCL 06
36 -
```

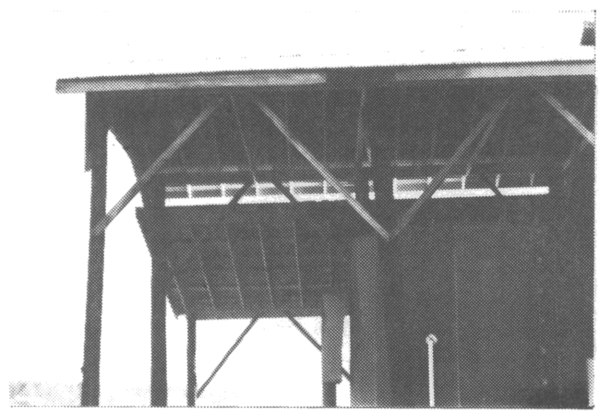
```
X^2
-
STO 08
4
*
CHS
RCL 02
X^2
2
*
+
LASTX
/
ACOS
STO 07
SIN
CHS
RCL 07
+
RCL 02
X^2
*
.0021645
*
ST+ 05
RCL 08
SQRT
RCL 03
*
.004329
*
ST+ 05
RCL 06
RCL 04
X>Y?
GTO 17
"GALLONS="
ARCL 05
AVIEW
BEEP
STOP
GTO 15
LBL 16
"RUNNING OVER"
AVIEW
BEEP
STOP
GTO 15
END
```

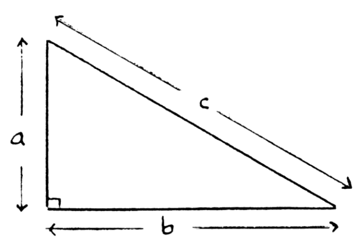
Chapter 9

CONSTRUCTION CALCULATIONS

Right Triangles

You may have learned a mathematical relationship in high school geometry class called the "Pythagorean theorem". This is just the relationship between the lengths of the sides of a right triangle, and it has several applications in construction work. The hypotenuse (side c in the diagram below) is the side opposite the right angle. Sides a and b are the sides adjacent to the right angle.





$c^2 = a^2 + b^2$
(Pythagorean theorem)

Suppose you are building a side shed, and you have pre-cut rafters and poles of a certain length. In this case, you know the rise (a) and the rafter length (c), and you want to find the run (b). (i.e. You want to know where to place the poles.) Then

$$b = \sqrt{c^2 - a^2}$$

Algebraic (without an $\boxed{x^2}$ key or memory)
1. key in rise
2. X
3. =
   a^2 displayed (record this value)
4. key in rafter length
5. X
6. =

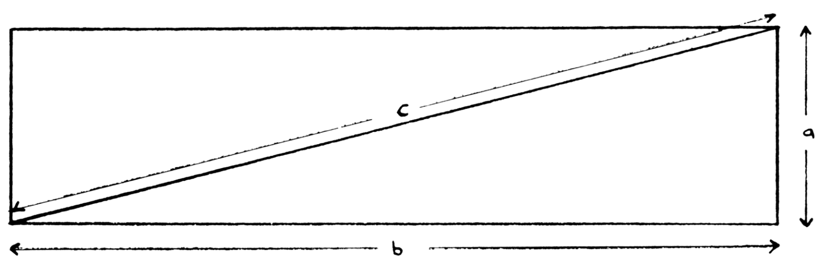
7. -
8. key in a^2
9. =
10. $\sqrt{x}$
    run displayed

Algebraic
1. key in rafter length
2. x^2
3. -
4. key in rise
5. x^2
6. =
7. $\sqrt{x}$
   run displayed

RPN
1. key in rafter length
2. x^2
3. key in rise
4. x^2
5. -
6. $\sqrt{x}$
   run displayed

NOTE: If you want to find the rise instead, you can swap a and b. If you want to find the rafter length for a given rise and run, you can use the sequence for the diagonal of a foundation (coming up next).

Now suppose you are trying to square a foundation. You know the lengths of the two sides, and you want to determine the length of a diagonal.



This time you want to find c instead.

Algebraic (without an x^2 key or memory)
1. key in one side length
2. X
3. =
   a^2 (or b^2) displayed (record this value)
4. key in other side length
5. X
6. =
7. +
8. key in a^2 (or b^2)
9. =
10 $\sqrt{x}$
   diagonal length displayed

Algebraic
1. key in one side
2. x^2
3. +
4. key in other side
5. x^2
6. =
7. $\sqrt{x}$
   diagonal displayed

RPN
1. key in one side
2. x^2
3. key in other side
4. x^2
5. +
6. $\sqrt{x}$
   diagonal displayed

Material Volumes

We will work some example problems using the methods presented in Chapter 8 and some unit conversions from Chapter 2.

(1) Board feet: A board foot is actually a unit of volume. It is the volume of a rectangular board with an area of one square foot and one inch thick. In cubic inches this is

$$(12 \text{ in.})(12 \text{ in.})(1 \text{ in.}) = 144 \text{ in.}^3$$

If you have ten 2X4 boards, and each board is 8 ft. long, then the volume of your lumber is

$$(10 \text{ boards})(8 \text{ ft./board})(12 \text{ in./ft.})(2 \text{ in.})(4 \text{ in.}) = 7680 \text{ in.}^3$$

or,

$$\frac{7680 \text{ in.}^3}{144 \text{ in.}^3\text{/board ft.}} = 53.33 \text{ board ft.}$$

(2) Yards of concrete: A yard of concrete is a unit of volume equal to one cubic yard. Also,

$$1 \text{ yd.}^3 = (3 \text{ ft.})(3 \text{ ft.})(3 \text{ ft.}) = 27 \text{ ft.}^3$$

$$= (36 \text{ in.})(36 \text{ in.})(36 \text{ in.}) = 46{,}656 \text{ in.}^3$$

Suppose you are pouring a foundation which is 20 ft. X 30 ft. and 6 inches deep. Then the volume in cubic feet is

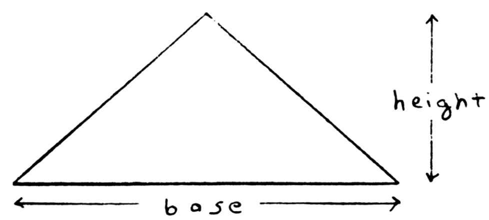
$$(20 \text{ ft.})(30 \text{ ft.})(.5 \text{ ft.}) = 300 \text{ ft.}^3$$

or,

$$\frac{300 \text{ ft.}^3}{27 \text{ ft.}^3/\text{yd.}^3} = 11.11 \text{ (yards of concrete)}$$

Material Areas

Most of the areas you deal with in construction work are either rectangular or triangular. Returning to the gambrel roof barn example in the previous chapter, we first found the area of half of the front of the barn. The area of a rectangle is just the product of the two sides. The area of a triangle is just one half the base times the height.



The area of the front of the barn was 2(375 ft.^{2}) = 750 ft.^{2}. If we wanted to cover the front of the barn with boards .5 in. thick, we would need

$$(750 \text{ ft.}^2)(144 \text{ in.}^2/\text{ft.}^2)(.5 \text{ in.}) = 54{,}000 \text{ in.}^3$$

or,

$$\frac{54{,}000 \text{ in.}^3}{144 \text{ in.}^3/\text{bdf.}} = 375 \text{ bdf.}$$

POSTSCRIPT

Although complete understanding of the accompanying explanations should not be required to use the keystrokes, by following the whole problem you should gain skill and confidence in using your pocket calculator. You may think of some applications which we haven't treated in this text and devise your own keystroke sequences. Some of the sequences listed were made a little longer than actually necessary so that it would be easier for you to follow along and understand the purpose of each keystroke.

If you want to begin writing your own programs, it would be helpful to study the function tables in your calculator owner's manual and then follow along some of the programs we have listed. This might be a little more difficult, because we have tried to streamline the programs in order to save program memory.

Pay particular attention to the GTO and LBL statements. GTO 15 changes the usual 1,2,3,4,... movement within the program and sends the program pointer to the line where LBL 15 is found. Notice also the conditional statements such as X>Y?. These functions compare the values in the x- and y-registers. If the answer to the question is "no", then the next line in the program is skipped.