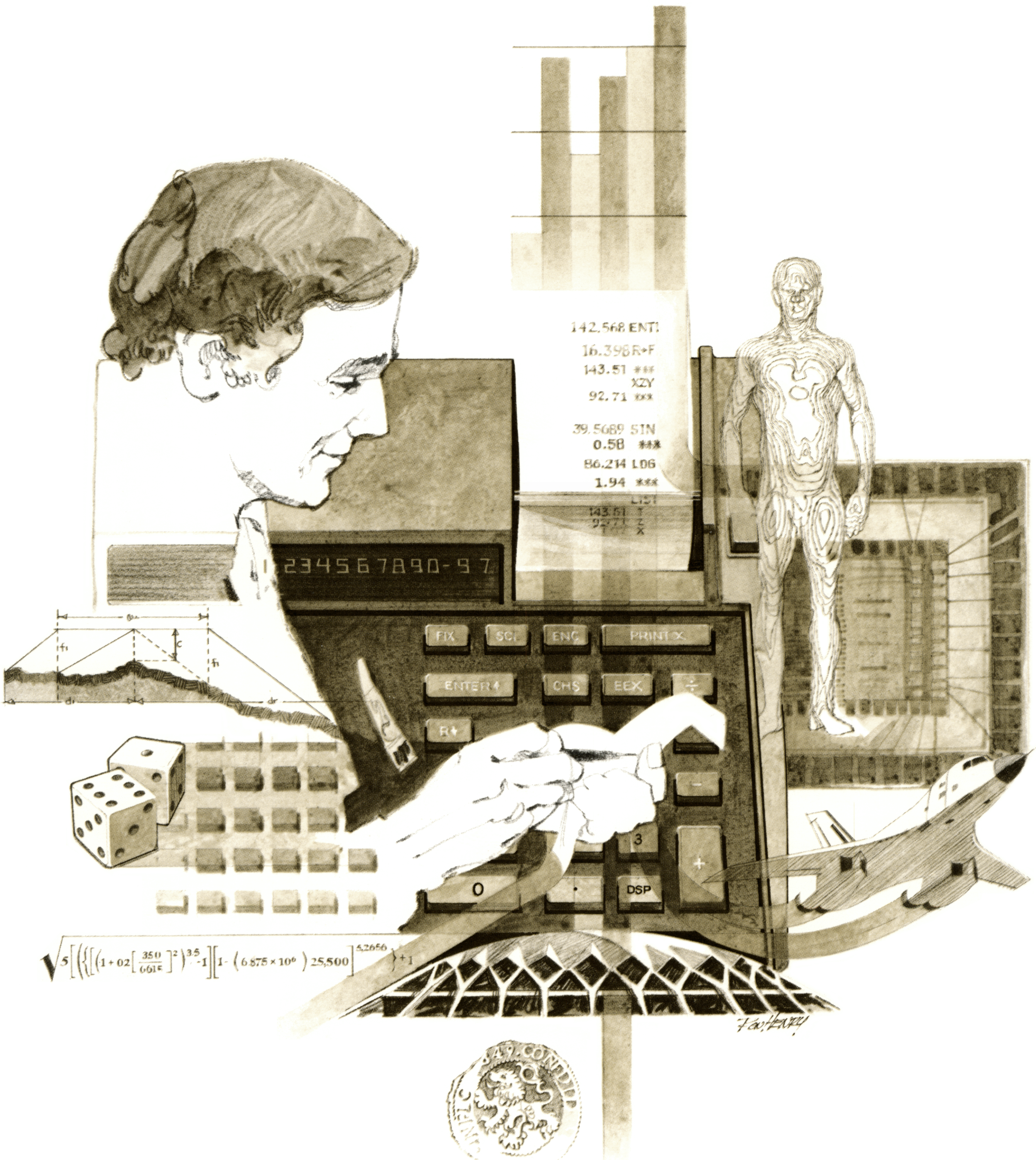
HEWLETT-PACKARD

HP-67/HP-97

Users' Library Solutions

Forestry



INTRODUCTION

In an effort to provide continued value to it's customers, Hewlett-Packard is introducing a unique service for the HP fully programmable calculator user. This service is designed to save you time and programming effort. As users are aware, Programmable Calculators are capable of delivering tremendous problem solving potential in terms of power and flexibility, but the real genie in the bottle is program solutions. HP's introduction of the first handheld programmable calculator in 1974 immediately led to a request for program **solutions** — hence the beginning of the HP-65 Users' Library. In order to save HP calculator customers time, users wrote their own programs and sent them to the Library for the benefit of other program users. In a short period of time over 5,000 programs were accepted and made available. This overwhelming response indicated the value of the program library and a Users' Library was then established for the HP-67/97 users.

To extend the value of the Users' Library, Hewlett-Packard is introducing a unique service—a service designed to save you time and money. The Users' Library has collected the best programs in the most popular categories from the HP-67/97 and HP-65 Libraries. These programs have been packaged into a series of low-cost books, resulting in substantial savings for our valued HP-67/97 users.

We feel this new software service will extend the capabilities of our programmable calculators and provide a great benefit to our HP-67/97 users.

A WORD ABOUT PROGRAM USAGE

Each program contained herein is reproduced on the standard forms used by the Users' Library. Magnetic cards are not included. The Program Description I page gives a basic description of the program. The Program Description II page provides a sample problem and the keystrokes used to solve it. The User Instructions page contains a description of the keystrokes used to solve problems in general and the options which are available to the user. The Program Listing I and Program Listing II pages list the program steps necessary to operate the calculator. The comments, listed next to the steps, describe the reason for a step or group of steps. Other pertinent information about data register contents, uses of labels and flags and the initial calculator status mode is also found on these pages. Following the directions in your HP-67 or HP-97 **Owners' Handbook and Programming Guide,** "Loading a Program" (page 134, HP-67; page 119, HP-97), key in the program from the Program Listing I and Program Listing II pages. A number at the top of the Program Listing indicates on which calculator the program was written (HP-67 or HP-97). If the calculator indicated differs from the calculator you will be using, consult Appendix E of your **Owner's Handbook** for the corresponding keycodes and keystrokes converting HP-67 to HP-97 keycodes and vice versa. No program conversion is necessary. The HP-67 and HP-97 are totally compatible, but some differences do occur in the keycodes used to represent some of the functions.

A program loaded into the HP-67 or HP-97 is not permanent—once the calculator is turned off, the program will not be retained. You can, however, permanently save any program by recording it on a blank magnetic card, several of which were provided in the Standard Pac that was shipped with your calculator. Consult your **Owner's Handbook** for full instructions. A few points to remember:

> The Set Status section indicates the status of flags, angular mode, and display setting. After keying in your program, review the status section and set the conditions as indicated before using or permanently recording the program.
>
> REMEMBER! To save the program permanently, **clip** the corners of the magnetic card once you have recorded the program. This simple step will protect the magnetic card and keep the program from being inadvertently erased.

As a part of HP's continuing effort to provide value to our customers, we hope you will enjoy our newest concept.

TABLE OF CONTENTS

Program Description I

Program Title Log Volume in Cubic Feet, Cubic Meters, or Board Feet

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

Given a log of diameter inside bark at the small end, d, length in feet, L, and taper in inches per 4 feet lineal, t, the program will:

Compute cubic foot volume according to the formula

$$V_c = \frac{\pi\left(d + \frac{tL}{8}\right)^2 L}{576}$$

Compute board foot volume by the International ¼" Log Rule,

$$V_b = \sum_{i=1}^{n} v_i + p v_{n+1}$$

where

v_i = cubic foot volume in the ith 4-foot bolt

$= 2\, d_i'^2 - .64\, d_i'$

and

d_i' = diameter in inches of the ith 4-ft. bolt at the small end,

p = length of the last (partial) bolt expressed as a proportion of 4 feet,

n = number of full 4-ft. bolts.

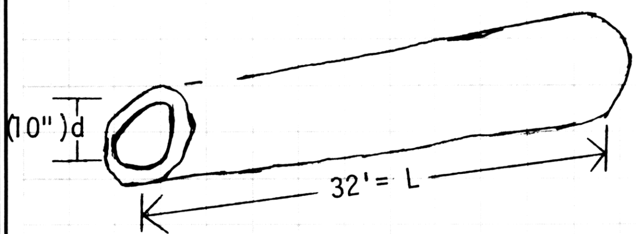
Compute cubic meter volume $V_m = V_c/35.314$

Operating Limits and Warnings

Board foot volumes will not match published tables because the program does not round off to the nearest 5 board feet.

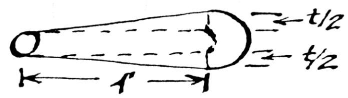
Program Description II

Sketch(es)



SAMPLE LOG

t=taper



TAPER

Sample Problem(s)

Find the log volume in cubic feet, International Log Rule board feet, and cubic meters of a log 10 inches in diameter (inside bark) at the small end and 32 feet in length with an average taper of ½" per 4 lineal feet.

Solution(s)

.5 [A] 10 [↑] 32 [B] [C] --------------------> 25.13 (V_c)

[D] --> 162.84 (V_b)

[E] --> 0.71 (Y_m)

Reference(s)

This program is a translation of the HP-65 User's Library program #1527A submitted by Larry Streeby.

Dilworth, Jr., Log Scaling and Timer Cruising, pags. 14-16, 25-28, O.S.U. Bookstores, 1968.

User Instructions

1	Log Volume in Cubic Feet, Cubic Meters, or Board Feet.				2
t	d ↑ L	ft^3	Bd.ft.	m^3	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1				
2.	Enter taper	t	A		t
3.	Enter diameter	d	↑		d
4.	Enter length	L	B		d
5.	Compute V_c		C		V_c
	or				
	Compute V_b		D		V_b
	or				
	Compute V_m		E		V_m
	(For a new case with the same t, go to step 3.)				
	(For a new case with the same t and d, but a new L, go to step 3--ie., enter both d & L.)				
	(After step 5, it is not necessary to do steps 1,2,&3 before another step 5 is done.)				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	STO1	35 01	$t \to R^1$
003	RTN	24	
004	*LBLB	21 12	
005	STO2	35 02	Store: $d \to R_3$
006	X⇄Y	-41	$L \to R_2$
007	STO3	35 03	
008	RTN	24	
009	*LBLC	21 13	
010	RCL3	36 03	
011	RCL1	36 01	
012	RCL2	36 02	
013	×	-35	
014	8	08	
015	÷	-24	Compute V_c
016	+	-55	
017	X²	53	
018	Pi	16-24	
019	×	-35	
020	5	05	
021	7	07	
022	6	06	
023	÷	-24	
024	RCL2	36 02	
025	×	-35	
026	RTN	24	
027	*LBLD	21 14	Compute V_b
028	CF1	16 22 01	
029	1	01	
030	STO4	35 04	Initialize p
031	0	00	
032	STO5	35 05	Initialize V_b
033	RCL3	36 03	Initialize d' to d
034	STO6	35 06	
035	RCL2	36 02	Initialize L' to L
036	STO7	35 07	
037	*LBL1	21 01	Determine if
038	RCL7	36 07	current bolt is
039	4	04	last one;
040	X≤Y?	16-35	Test 4≤L'?
041	GTO2	22 02	
042	RCL7	36 07	Last bolt:
043	4	04	Calculate p
044	÷	-24	
045	STO4	35 04	Last bolt:
046	SF1	16 21 01	Flag on
047	*LBL2	21 02	
048	RCL6	36 06	Compute 4' bolt
049	X²	53	volume
050	.	-62	
051	2	02	
052	×	-35	
053	RCL6	36 06	
054	.	-62	
055	6	06	
056	4	04	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	×	-35	
058	-	-45	Reduce V_b for last
059	RCL4	36 04	
060	×	-35	(partial) bolt
061	RCL5	36 05	
062	+	-55	
063	STO5	35 05	V_b update$\to R_5$
064	F1?	16 23 01	Test: last bolt?
065	RTN	24	Stop
066	RCL7	36 07	
067	4	04	Update L'
068	-	-45	
069	STO7	35 07	
070	RCL6	36 06	
071	RCL1	36 01	Compute V_b for
072	+	-55	
073	STO6	35 06	next bolt
074	GTO1	22 01	
075	*LBLE	21 15	
076	GSBC	23 13	
077	3	03	
078	5	05	Convert V_c to V_m
079	.	-62	
080	3	03	
081	1	01	
082	4	04	
083	÷	-24	
084	RTN	24	
085	R/S	51	
090			
100			
110			

FLAGS	
0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☑
1	☐	☑
2	☐	☑
3	☐	☑

TRIG	
DEG	☑
GRAD	☐
RAD	☐

DISP	
FIX	☑
SCI	☐
ENG	☐
n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	t	L	d	p	V_b	d'	L'		

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title LUMBER SCALE - BOARD FEET RECOVERABLE FROM A LOG

Contributor's Name HEWLETT-PACKARD, Corvallis Division

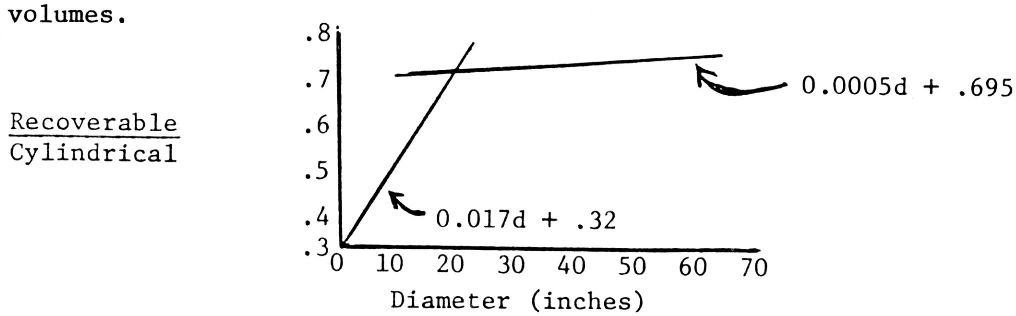
Address 1000 N. E. Circle Blvd.

City Corvallis **State** OR **Zip Code** 97330

Program Description, Equations, Variables Given the length, small and large diameters of a log, this program computes the cylindrical and recoverable board feet of a log.

Rules:

1. For butt logs, the large diameter is calculated from the small diameter and the length assuming a linear taper of 1 in. in 10 ft.
2. All log sections must be cut to an even foot length.
3. Logs longer than 20 ft. must be cut to nearly equal length segments subject to 2 above.
4. The volume of a section is that of the right circular cylinder with diameter of the small end.
5. The waste resulting from trimming and saw kerf is a function of log diameter and is expressed as a ratio of the recoverable to the calculated cylindrical volumes.



Notation:

ℓ = length of log - ft	CBF = Cylindrical board feet
d_s = diameter of small end	RBF = Recoverable board feet
d_L = diameter of large end	ℓ_c = length of section cut
sl = slope of log	RD = function which rounds down to nearest even integer

Program Description I

Program Title LUMBER SCALE - BOARD FEET RECOVERABLE FROM A LOG

Contributor's Name Hewlett-Packard, Corvallis Division
Address 1000 N. E. Circle Blvd.
City Corvallis **State** OR **Zip Code** 97330

Program Description, Equations, Variables

Notation:

ℓ = length of log - ft	CBF = Cylindrical board feet
d_s = diameter of small end	RBF = Recoverable board feet
d_L = diameter of large end	ℓ_c = length of section cut
sl = slope of log	RD = function which rounds down to nearest even integer

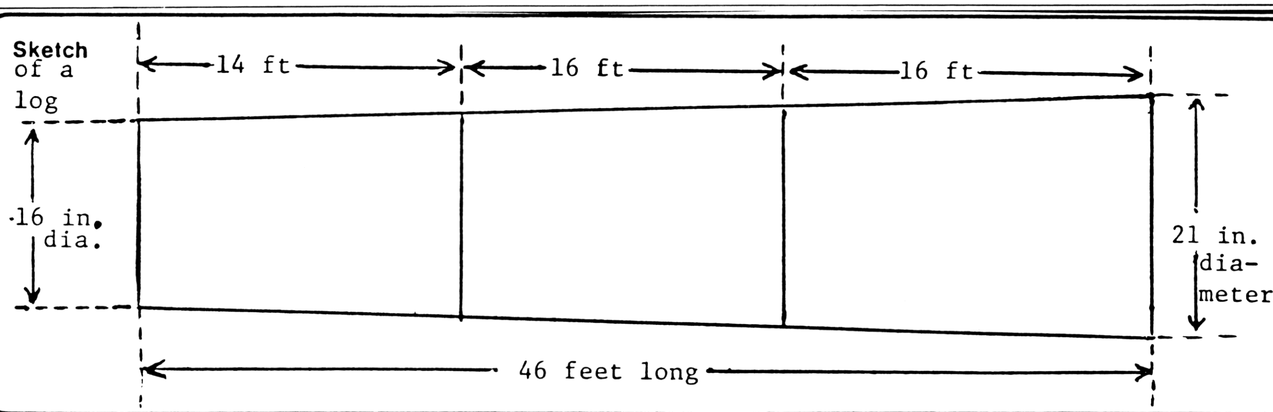
Algorithm:

Enter 1, d_s, d_L (d_L is entered as 0 for a butt log)

$\ell \leftarrow RD(\ell)$	Round ℓ down
If $d_L \leq 0$, $d_L \leftarrow d_s + (.1 x \ell)$	d_L for butt log
$SL \leftarrow (d_L - d_s)/\ell$	Compute slope
$\Sigma CBF \leftarrow \Sigma RBF \leftarrow 0$	Initialize accumulators
Repeat until $\ell \leq 0$	
$ns \leftarrow INT[(\ell+19)/20]$	Number of sections remaining
$\ell_c \leftarrow RD(\ell/ns)$	Length of this cut
$CBF \leftarrow \pi d_s^2 \ell_c / 48$	Cylindrical board feet
$\Sigma CBF \leftarrow \Sigma CBF + CBF$	Accumulate CBF
If $d_s \leq 22$	Select ratio equation coefficients
then $A \leftarrow .017$, $B \leftarrow .32$	
else $A \leftarrow .0005$, $B \leftarrow .695$	
$RBF \leftarrow CBF x (A x d_s + B)$	Recoverable board feet
$\Sigma RBF \leftarrow \Sigma RBF + RBF$	Accumulate RBF
$\ell \leftarrow \ell - \ell_c$	Remove length of this cut
$d_s \leftarrow d_s + (\ell_c x SL)$	Increase small diameter
end repeat	

Program Description II

Sketch of a log



Sample Problem(s) Find the recoverable and cylindrical board feet in a log that is 46 feet long with end diameters of 16 and 21 inches.

Solution(s)

1) Load Side 1
2) 46[A] 16[B] 21[C][D] → 0.109 = SL
3) [f][A] → 588.586 = RBF
4) [f][B] → 839.917 = CBF

Reference(s) This program is a translation of the HP-65 User's Library program #01925A Submitted by Eric R. Pianka. USDA Forest Service Handbook R5-2400

User Instructions

LUMBER SCALE PROGRAM

1 → RBF	→ CBF			2

ℓ	d_s	d_L	→ SL

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load Side 1				
2	Enter data	ℓ	A		ℓ
3	Enter data	d_s	B		d_s
4	Enter data	d_L	C		d_L
5	Compute and initialize		D		SL
6	Compute total RBF		f	A	RBF
7	Display total CBF		f	B	CBF
	Register Assignments:				
	R_1 = ℓ-decreased after each cut				
	R_2 = d_s-increased after each cut				
	R_3 = d_L				
	R_4 = ΣCBF				
	R_5 = ΣRBF				
	R_6 = SL				
	R_7 = ℓc				
	R_8 = CBF				

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	3

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	STO1	35 01	$\ell \rightarrow R_1$
003	RTN	24	
004	*LBLB	21 12	
005	STO2	35 02	$d_s \rightarrow R_2$
006	RTN	24	
007	*LBLC	21 13	
008	STO3	35 03	$d_L \rightarrow R_3$
009	RTN	24	
010	*LBLD	21 14	
011	RCL1	36 01	
012	INT	16 34	$INT[\ell] \rightarrow R_1$
013	STO1	35 01	
014	RCL3	36 03	
015	X>0?	16-44	$d_L > 0$?
016	GTO2	22 02	Yes, GTO 2
017	RCL1	36 01	
018	.	-62	
019	1	01	
020	x	-35	
021	RCL2	36 02	$d_s + (.1\ell) - d_L \rightarrow R_3$
022	+	-55	
023	STO3	35 03	
024	*LBL2	21 02	
025	0	00	$0 \rightarrow R_4, R_5$
026	STO4	35 04	
027	STO5	35 05	
028	RCL3	36 03	
029	RCL2	36 02	$\frac{d_L - d_s}{\ell} \rightarrow R_6$
030	-	-45	
031	RCL1	36 01	
032	÷	-24	
033	STO6	35 06	
034	RTN	24	
035	*LBLa	21 16 11	
036	RCL1	36 01	
037	ENT↑	-21	$\frac{\ell}{INT[\frac{(\ell+19)}{20}]} = \ell_c$
038	ENT↑	-21	
039	1	01	
040	9	09	
041	+	-55	
042	2	02	$\ell_c \rightarrow R_7$
043	0	00	
044	÷	-24	
045	INT	16 34	
046	÷	-24	
047	2	02	
048	÷	-24	
049	INT	16 34	
050	2	02	
051	x	-35	
052	STO7	35 07	
053	RCL2	36 02	
054	X²	53	
055	.	-62	
056	0	00	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	6	06	
058	5	05	$0.0654\ (\ell_c)(d_s)^2$
059	4	04	
060	x	-35	
061	x	-35	$= CBF \rightarrow R_8$
062	STO8	35 08	
063	ST+4	35-55 04	$\Sigma CBF \rightarrow R_4$
064	2	02	
065	2	02	$d_s \leq 22$?
066	RCL2	36 02	
067	X≤Y?	16-35	
068	GTO3	22 03	
069	5	05	$0.0005\ d_s$
070	EEX	-23	
071	4	04	
072	CHS	-22	
073	x	-35	
074	.	-62	
075	6	06	
076	9	09	
077	5	05	
078	GTO4	22 04	
079	*LBL3	21 03	
080	.	-62	$0.017\ d_s$
081	0	00	
082	1	01	
083	7	07	
084	x	-35	
085	.	-62	
086	3	03	
087	2	02	
088	*LBL4	21 04	
089	+	-55	
090	RCL8	36 08	
091	x	-35	$\Sigma RBF \rightarrow R_5$
092	ST+5	35-55 05	
093	RCL7	36 07	
094	RCL1	36 01	
095	X≤Y?	16-35	
096	GTO1	22 01	
097	-	-45	
098	CHS	-22	
099	STO1	35 01	
100	RCL7	36 07	
101	RCL6	36 06	
102	x	-35	
103	ST+2	35-55 02	
104	RCL2	36 02	
105	GTOa	22 16 11	Show ΣRBF
106	*LBL1	21 01	
107	RCL5	36 05	
108	RTN	24	
109	*LBLb	21 16 12	Show ΣCBF
110	RCL4	36 04	
111	GTOa	22 16 11	
112	R/S	51	

REGISTERS

0	1	2	3	4	5	6	7	8	9
	ℓ	d_s	d_L	ΣCBF	ΣRBF	SL	ℓ_c	CBF	
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title LOGGING CALCULATIONS - DOYLE'S METHOD

Contributor's Name Hewlett-Packard, Corvallis Division

Address 1000 N. E. Circle Blvd.

City Corvallis **State** OR **Zip Code** 97330

Program Description, Equations, Variables Given average spacing of trees in x & y directions, the program calculates number of trees per acre = $\frac{209}{x} \times \frac{209}{y}$ (with x & y in feet)

Number of trees per hectare = $\frac{100}{x} \times \frac{100}{y}$ (with x & y in meters)

1 acre = a 209 ft. square

1 hectare = a 100m square

Given

Log length L, in feet,
Log top diameter (under bark) D, in inches,

The program solves for board-feet using the equation (Doyle's)

$$\text{Vol} = \frac{(D-4)^2 L}{16} \text{ (board-feet)}$$

Cubic feet are calculated, 12 board-ft = $1 ft^3$
423.7 bd-ft = $1 m^3$

Operating Limits and Warnings D & L must be in inches and feet, respectively. Accuracy is plus or minus 5-10%, depending in part on accuracy in taking timber inventory.

Program Description II

Sketch(es)

Sample Problem(s)

1. A tree farm is planting trees with 15-ft spacing in both directions. The trees, when harvested, will produce one log of average-length 40 ft., and average top diameter of 12 inches under the bark.
   How many trees can be grown per acre, and how much sawn lumber can be expected per acre?

2. A timber inventory shows that average spacing of trees 15cm and over is five by five meters. 10.5 hectares of land are to be cleared.
   How many trees, 15 cm and over must be felled to clear the land?

Solution(s)

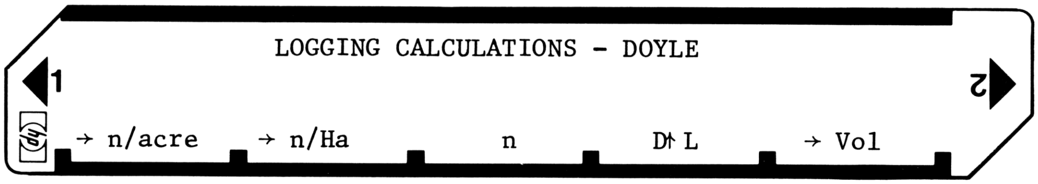
1) 15[ENTER ↑] 15[A] → 194.14 trees/acre
   12[ENTER ↑]40 [D][E] → 31062.04 bd. ft.
   [R/S] → 2588.50 ft^3
   [R/S] → 73.31 m^3

2) 5[ENTER ↑] 5[B] → 400 trees/hectare
   10.5[x] → 4200 trees

Reference(s)

This program is a translation of the HP-65 Users' Library Program No. 01711A
Submitted by Michael I. Kingery.
Caterpillar Handbook, 1970 Edition, Sec. 17, pages 22-24

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load side 1.				
2	Enter spacing of trees in x direction, feet	x	↑		x
3	Enter spacing of trees in y direction, feet	y	A		n/acre
2	Enter spacing of trees in x direction, meters	x	↑		x
3	Enter spacing of trees in y direction, meters	y	B		n/Ha
4	Enter number of logs (if not already calcu-		↑		
	lated)	n	C		n
5	Enter top diameter of logs, inches	D	↑		D
6	Enter log length, feet	L	D		L
7	Calculate volume, board-feet		E		bd-ft
8	(Optional) Calculate volume in cubic feet		R/S		ft^3
9	(Optional) Calculate volume in cubic meters		R/S		m^3
	Return to Step 2 or 4 for new problems.				
	NOTE: Steps 2 & 3 are independant of steps				
	4 - 9.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	$y \rightarrow R_2$
002	STO2	35 02	
003	R↓	-31	
004	STO1	35 01	$x \rightarrow R_1$
005	2	02	
006	0	00	
007	9	09	
008	GTO0	22 00	
009	*LBLB	21 12	$y \rightarrow R_2$
010	STO2	35 02	
011	R↓	-31	$x \rightarrow R_1$
012	STO1	35 01	
013	EEX	-23	
014	2	02	
015	*LBL0	21 00	
016	X^2	53	$\frac{(209)^2 \text{ or } (100)^2}{xy} = n$
017	RCL1	36 01	
018	÷	-24	
019	RCL2	36 02	
020	÷	-24	
021	STO3	35 03	$n \rightarrow R_3$
022	RTN	24	
023	*LBLC	21 13	
024	STO3	35 03	$n \rightarrow R_3$
025	RTN	24	
026	*LBLD	21 14	
027	STO5	35 05	$L \rightarrow R_5$
028	X⇄Y	-41	
029	STO4	35 04	$D \rightarrow R_4$
030	X⇄Y	-41	
031	RTN	24	
032	*LBLE	21 15	
033	RCL4	36 04	
034	4	04	
035	-	-45	$\frac{(D-4)^2 L}{16} \times n \rightarrow R_5$
036	X^2	53	
037	RCL5	36 05	
038	×	-35	
039	1	01	
040	6	06	
041	÷	-24	
042	RCL3	36 03	
043	×	-35	
044	STO5	35 05	
045	R/S	51	
046	1	01	$\frac{R_5}{12}$
047	2	02	
048	÷	-24	
049	R/S	51	
050	RCL5	36 05	
051	4	04	$\frac{R_5}{423.7}$
052	2	02	
053	3	03	
054	.	-62	
055	7	07	
056	÷	-24	
057	RTN	24	
058	R/S	51	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	x	y	n trees	n logs	L	Total board-ft in n logs			

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Cruiser's Stick for Forest Mensuration

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables A Biltmore stick is used to measure tree diameter. Used properly, the following formula will convert inches (cm) on a normal stick, to diameter:

$$D = 2 \left(\frac{a}{a/.5g - 1}\right) \quad \text{where:}$$

D = Diameter of tree; a = Cruiser's reach (eye to stick) and g = in (cm) read off the stick.

The Merritt hypsometer presumes the cruiser to be a known distance from the tree. Tree height is found by the following:

$$Z = \frac{d\ g}{a} \quad \text{where:}$$

Z = Tree height; d = distance from tree and a and g are as above.

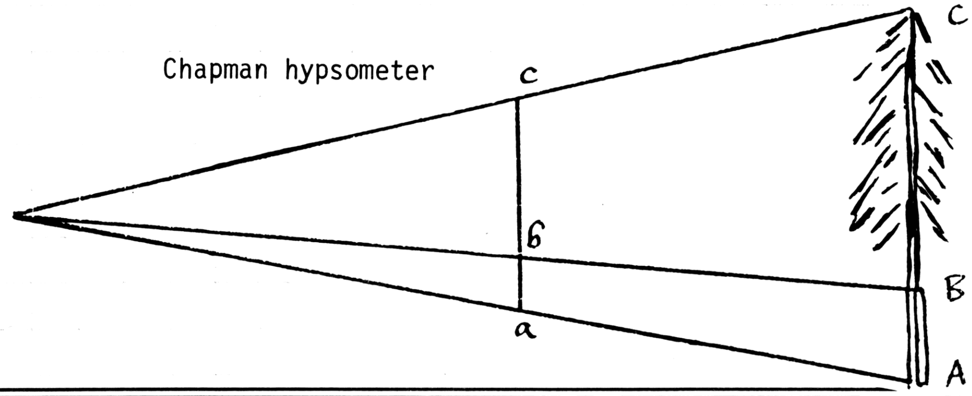
The Chapman Hypsometer allows the cruiser to be any distance from the tree, but requires an object of known height to be beside the tree for reference. See sketch:

$$AC = \frac{(AB)(ac)}{ab}$$

Operating Limits and Warnings

Program Description II

Sketch(es)



Sample Problem(s) (a) Using a yardstick, a cruiser with a 25" reach measures the apparent diameter of a tree to be 10", and when standing 66' away, the apparent height is 30". What are the true dimensions?

(b) Using a meterstick, a cruiser with a 60 cm. reach measures the apparent diameter of a tree to be 35 cm. When a 1.85 m tall person standing by the tree appears to be 6 cm in height, the tree appears 75 cm high. What are the true dimensions?

Solution(s) (a) 25[A] 10[B] -----------> 13" diameter. Using the Merritt Hypsometer:
66[↑] 30[C] ---------------------> 79.20' high
Presuming 16' logs: 16[R/S] ---> 4.5 logs

(b) 60[A] 35[B] ----------------> 49 cm diameter. Using the Chapman Hypsometer:
1.85[D] 6[↑] 75[E]---------------> 23.13 m high
To convert to 16' logs, this must be changed to feet; or it can be converted to 5 m logs by removing flag one, to wit: [CLF] [1] 5[R/S]---> 4 logs.
(But see footnote 2, page 3).

Reference(s) This program is a translation of the HP-65 Users' Library program #02521A submitted by Randall Lee O'Toole.

Chapman and Meyer, <u>Forest Mensuration</u>. McGraw-Hill, New York.

User Instructions

CRUISER'S STICK

1 ◀ ▶ 2

Reach	Diam	d↑ a→Ht	A B	a↑ bc→Ht

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1.				
2.	For Biltmore stick and Merritt hypsometer:				
	key in reach.	in or cm	A		
3.	For Biltmore stick: key in apparent diameter,				
	read true diameter.[1]	in or cm	B		in or cm
4.	For Merritt hypsometer: enter distance from				
	tree.	ft or m	↑		
5.	Key in apparent tree height, read true height	in or cm	C		ft or m
6.	Unless already entered[2], key in log length,				
	read tree height in logs[3]	ft or m	R/S		logs
7.	If log length already entered, it will not need				
	to be re-entered.				
8.	For Chapman Hypsometer: enter height of				
	reference object. This does not need to be				
	repeated.	ft or m	D		
9.	Key in apparent ht. of reference object	in or cm	↑		
10.	Enter tree's apparent height; read true height	in or cm	E		ft or m
11.	Go to 6 for height of tree in logs.				
	FOOTNOTES:				
	1. Program rounds to nearest inch (or cm)				
	2. To change log length, key in:		CLF	1	
	and input new length at appropriate time.				
	Program allows 4"(.3') for bucking; if				
	meters will be the usual units, change key				
	entry 31 from "03" to "01".				
	3. Program rounds to the nearest one-half				
	log downward.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Stores cruiser's reach Biltmore & Merritt.
002	STO1	35 01	
003	RTN	24	
004	*LBLB	21 12	Calculation of true diameter
005	2	02	
006	÷	-24	
007	RCL1	36 01	
008	X⇄Y	-41	
009	÷	-24	
010	1	01	
011	-	-45	
012	RCL1	36 01	
013	X⇄Y	-41	
014	÷	-24	
015	2	02	
016	x	-35	
017	.	-62	
018	5	05	Round to nearest whole inch (cm)
019	+	-55	
020	INT	16 34	
021	RTN	24	
022	*LBLC	21 13	
023	x	-35	
024	RCL1	36 01	Calculation of tree length (Merritt)
025	÷	-24	
026	R/S	51	
027	*LBL2	21 02	
028	F1?	16 23 01	Conversion to logs
029	GTO0	22 00	
030	.	-62	
031	3	03	
032	+	-55	
033	STO3	35 03	
034	R↓	-31	Standard log length
035	SF1	16 21 01	
036	*LBL0	21 00	
037	RCL3	36 03	Flag set when standard log length stored
038	÷	-24	
039	STO5	35 05	
040	FRC	16 44	
041	.	-62	
042	5	05	Round to nearest one-half log downwards.
043	X≤Y?	16-35	
044	GTO1	22 01	
045	RCL5	36 05	
046	INT	16 34	
047	R/S	51	
048	*LBL1	21 01	
049	RCL5	36 05	
050	INT	16 34	
051	+	-55	
052	R/S	51	
053	*LBLD	21 14	
054	STO4	35 04	Store height of reference
055	RTN	24	
056	*LBLE	21 15	
057	RCL4	36 04	Calculation of tree height (Chapman)
058	x	-35	
059	X⇄Y	-41	
060	÷	-24	
061	R/S	51	
062	GTO2	22 02	Conversion to height in logs.
063	R/S	51	
070			
080			
090			
100			
110			

FLAGS	
0	
1	Used
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	Reach(a)		Used	Used	Used				

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title True Productivity of a Natural Coniferous Forest

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables Stand density index, the number of trees per acre of a stand at the quadratic mean diameter of 10", allows a refinement of productivity estimations over simple site index. On log paper, the maximum tpa over quadratic mean diameter assumes a straight line. The general equation holds:

$$\text{LOG } N = -C \log D + S$$

where

N is the number of trees per acre

C is a constant varying by species

D is the quadratic mean diameter and

S is the normal stand density index of a species, i.e. the sdi at the stocking levels of normal yield tables.

For western conifers, the values of C and S which have been found are shown below. The values appropriate to ponderosa pine are coded on the program form, and the others can be substituted at need.

The program is to be used following a variable plot cruise in which the diameter of every metchantable tree is to be measured. Unmerchantable trees are to be

Operating Limits and Warnings

By "natural", it is implied that recently burned or harvested stands could easily produce misleading results. Stumps and snags must be counted in such areas, but unless the disturbance was very recent or very long ago, underestimation of the productivity is likely.

Program Description I

Program Title True Productivity of a Natural Coniferous Forest

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables measured when, in the cruisers judgement, they could be replaced by merchantable species (this is rare). The prism basal area factor, tree diameters and number of plots are entered and the stand density index calculated. The true productivity can be found by then entering the productivity as estimated by site index alone.

In a variable plot cruise, each tree represents a number of trees per acre depending on its basal area, i.e.,

Trees per acre = Basal Area Factor/Basal area of tree

VALUES OF C AND S

SPECIES	C	S
True firs, hemlocks, redcedar, white pine & spruce	1.605	500
Mixed conifer (cedar, fir, Douglas fir & pines)	1.605	370
Douglas-fir	1.55	370
Ponderosa and Jeffrey pine	1.80	370
Lodgepole pine	1.80	300

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s) The productivity of a ponderosa pine stand as estimated by site index is 80 cubic feet per acre per year. Based on the following plot data, what is the true productivity? A 40 BAF prism was used.

	sp.	DBH		sp.	DBH
Plot one -	P_p	30"	Plot two -	P_p	45"
		42"			28"
		25"			32"
					40"

Solution(s)

[A] 40[B] 30[C] 42[C] 25[C] 45[C]

28[C] 32[C] 40[C] 2(plots)[D] ----------------------> 202.94 (SDI)

80[E] --> 43.88 ≃ 44 cubic feet/acre/year.

Reference(s)

USDI BLM. Bureau of Land Management Manual Supplement 5250, release 5-113, Portland, Oregon, 1974.

This program is a translation of the HP-65 Users' Library program #02522A submitted by Randal Lee O'Toole.

User Instructions

TRUE PRODUCTIVITY OF A CONIFEROUS FOREST

1 | 2

Initial | BAF | DBH | # Plots | Prod.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1				
2.	Initialize		A		
3.	Enter prism BAF	BAF	B		
4.	Enter tree diameters	DBH	C		trees per acre
5.	Repeat step 4 until all suitable trees entered				
6.	Enter number of variable plots		D		Stand den. index
7.	Enter site index-estimated productivity, read true productivity	cu'/acre/yr			cu'/acre/yr
8.	To repeat for next plot or group of plots, go to step 3. Initialization does not affect BAF.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Initialize
002	0	00	
003	STO2	35 02	
004	STOI	35 46	
005	RTN	24	
006	*LBLB	21 12	Stores Basal Area Factor
007	STO1	35 01	
008	RTN	24	
009	*LBLC	21 13	Converts tree diameter to representative trees per acre.
010	2	02	
011	÷	-24	
012	X²	53	
013	Pi	16-24	
014	x	-35	
015	1	01	Conversion of DBH to Basal Area tpa=BAF/BA
016	4	04	
017	4	04	
018	÷	-24	
019	RCL1	36 01	
020	X⇄Y	-41	
021	÷	-24	
022	.	-62	
023	5	05	
024	+	-55	
025	INT	16 34	
026	ST+2	35-55 02	
027	ISZI	16 26 46	Counter
028	RTN	24	
029	*LBLD	21 14	Determines stand density index
030	STO3	35 03	
031	RCL2	36 02	
032	X⇄Y	-41	
033	÷	-24	
034	STO2	35 02	
035	RCLI	36 46	
036	RCL3	36 03	
037	÷	-24	
038	RCL1	36 01	
039	x	-35	
040	RCL2	36 02	
041	÷	-24	
042	Pi	16-24	
043	÷	-24	
044	√X	54	
045	2	02	
046	4	04	
047	x	-35	
048	STO4	35 04	
049	LOG	16 32	
050	1	01	
051	-	-45	
052	1	01	C-variable by species. See page 2.
053	.	-62	
054	8	08	
055	x	-35	
056	RCL2	36 02	
057	LOG	16 32	
058	+	-55	
059	10ˣ	16 33	
060	STO5	35 05	
061	RTN	24	
062	*LBLE	21 15	Determines true productivity. S-variable by species. See page 2.
063	RCL5	36 05	
064	3	03	
065	7	07	
066	0	00	
067	÷	-24	
068	x	-35	
069	RTN	24	
070	R/S	51	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	BAF	TPA	#plots	Used	SDI				

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
					Counter

Program Description I

Program Title Mean Annual Increment of Douglas-Fir and Certain Pine Forests

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

This program uses formulae calculated from the most recent data available, by the Bureau of Land Management. They are:

$$MAI_{100\ years}(\text{D-fir}) = -10.303313 + (.032929911)\ SI + (.012207165)\ SI^2 - (.00003543129)\ SI^3;$$

$$MAI_{70\ years}(\text{Pine}) = 2.305357 + (.0033890056)\ SI + (.0090108543)\ SI^2$$

The latter equation applies to stands of sugar, ponderosa and Jeffrey pine.

MAI = mean annual increment in cubic feet/acre/year

SI = site index

Operating Limits and Warnings

The data from which these equations were derived was gathered on normally stocked stands in Oregon. The equations may not apply to under stocked stands, or stands outside of Oregon.

Program Description II

Sketch(es)

Sample Problem(s) Given the following site indices, calculate the appropriate MAI's:

	D-fir stands		Pine stands
a	150	b	160
c	70	d	80

Solution(s)

a 150[A] --------------------> 149.72

b 160[B] --------------------> 233.53

c 70[A] --------------------> 39.66

d 80[B] --------------------> 60.25

Reference(s)

USDI BLM (73). Bureau of Land Management Manual Supplement 5250 - Intensive Inventories, Portland, Oregon.

This program is a translation of the HP-65 Users' Library program #02542A submitted Randall Lee O'Toole.

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1				
2.	Key in D-fir				
	Site index	SI	A		cu'/acre/yr
3.	Key in pine				
	Site index	SI	B		cu'/acre/yr

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Douglas-fir equation
002	STO1	35 01	
003	3	03	
004	5	05	
005	4	04	
006	3	03	
007	1	01	
008	2	02	
009	9	09	
010	EEX	-23	
011	1	01	
012	1	01	
013	CHS	-22	
014	x	-35	
015	.	-62	
016	0	00	
017	1	01	
018	2	02	
019	2	02	
020	0	00	
021	7	07	
022	1	01	
023	6	06	
024	3	03	
025	-	-45	
026	RCL1	36 01	
027	x	-35	
028	.	-62	
029	0	00	
030	3	03	
031	2	02	
032	9	09	
033	2	02	
034	9	09	
035	9	09	
036	1	01	
037	1	01	
038	-	-45	
039	RCL1	36 01	
040	x	-35	
041	1	01	
042	0	00	
043	.	-62	
044	3	03	
045	0	00	
046	3	03	
047	3	03	
048	1	01	
049	3	03	
050	+	-55	
051	CHS	-22	
052	RTN	24	
053	*LBLB	21 12	Pine equation
054	STO2	35 02	
055	.	-62	
056	0	00	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	0	00	
058	9	09	
059	0	00	
060	1	01	
061	0	00	
062	9	09	
063	5	05	
064	4	04	
065	3	03	
066	x	-35	
067	.	-62	
068	0	00	
069	0	00	
070	3	03	
071	3	03	
072	8	08	
073	9	09	
074	0	00	
075	0	00	
076	5	05	
077	6	06	
078	+	-55	
079	RCL2	36 02	
080	x	-35	
081	2	02	
082	.	-62	
083	3	03	
084	0	00	
085	5	05	
086	3	03	
087	5	05	
088	7	07	
089	+	-55	
090	RTN	24	
091	R/S	51	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	D-fir SI	Pine SI							

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Mean Annual Increment of Various Forests

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables This program uses the following equations, as developed by the Bureau of Land Management:

$$MAI_{\text{W. hemlock, mtn hemlock, subalp.fir, w. red cedar, Sitka spruce}} = -63.689706 + (1.940291)\ SI_{100}$$

$$MAI_{\text{Lodgepole pine}} = -12.0388 + (1.18672)\ SI_{50}$$

$$MAI_{\text{W.White pine}} = 5.972615 + (1.857675) SI_{50}$$

$$MAI_{\text{Englemann spruce}} = -18.4 + (1.92)\ SI_{50}$$

$$MAI_{\text{Alder, Hardwoods}} = -53.892857 + (1.718571)\ SI_{50}$$

MAI_n is mean annual increment in cubic feet per acre per year for n species

SI_x is the site index at age x.

Operating Limits and Warnings

These equations apply to normally stocked stands in Oregon, and may have to be modified for poorly stocked stands or other states. Because of small data base, the equations are not as accurate as those for more valuable species, i.e., Douglas-fir, etc.

Program Description II

Sketch(es)

Sample Problem(s) Given the following site indices, calculate mean annual increments:

	Forest				
	Hemlock et al	Lodgepole	W.W.Pine	Alder	E. Spruce
	a 100	b 80	c 30	d 50	e 20
	f 120	g 60	h 70	i 60	j 50

Solution(s)

a. 100[A] ----------->	130.34	f. 120[A] ----------->	169.15
b. 80[B] ----------->	82.90	g. 60[B] ----------->	59.16
c. 30[C] ----------->	61.70	h. 70[C] ----------->	136.01
d. 50[D] ----------->	32.00	i. 60[D] ----------->	49.18
e. 20[E] ----------->	20.00	j. 50[E] ----------->	77.60

Reference(s) USDI BLM (73) Bureau of Land Management Manual Supplement 5250-Intensive Inventories, Portland, Oregon.

This program is a translation of the HP-65 Users' Library program #02713A submitted by Randall Lee O'Toole.

User Instructions

MAI of Various Forests

Hem.	Lodg.pine	W.W.pine	Alder	E.spruce

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1				
2.	Key in Hemlock et al site index	SI	A		cu'/acre/yr
3.	Key in Lodgepole pine site index	SI	B		cu'/acre/yr
4.	Key in W.W. pine site index	SI	C		cu'/acre/yr
5.	Key in Alder site index	SI	D		cu'/acre/yr
6.	Key in Englemann spruce site index	SI	E		cu'/acre/yr

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Western and mountain hemlock, subalpine fir, western red cedar, sitka spruce equation
002	1	01	
003	.	-62	
004	9	09	
005	4	04	
006	8	08	
007	2	02	
008	9	09	
009	4	04	
010	1	01	
011	x	-35	
012	6	06	
013	3	03	
014	.	-62	
015	6	06	
016	8	08	
017	9	09	
018	7	07	
019	0	00	
020	6	06	
021	-	-45	
022	RTN	24	
023	*LBLB	21 12	Lodgepole pine equation
024	1	01	
025	.	-62	
026	1	01	
027	8	08	
028	6	06	
029	7	07	
030	2	02	
031	x	-35	
032	1	01	
033	2	02	
034	.	-62	
035	0	00	
036	3	03	
037	8	08	
038	8	08	
039	-	-45	
040	RTN	24	
041	*LBLC	21 13	Western white pine equation
042	1	01	
043	.	-62	
044	8	08	
045	5	05	
046	7	07	
047	6	06	
048	7	07	
049	5	05	
050	x	-35	
051	5	05	
052	.	-62	
053	9	09	
054	7	07	
055	2	02	
056	6	06	
057	1	01	
058	5	05	
059	+	-55	
060	RTN	24	
061	*LBLD	21 14	Alder and hardwoods equation
062	1	01	
063	.	-62	
064	7	07	
065	1	01	
066	7	07	
067	8	08	
068	5	05	
069	7	07	
070	1	01	
071	x	-35	
072	5	05	
073	3	03	
074	.	-62	
075	8	08	
076	9	09	
077	2	02	
078	8	08	
079	5	05	
080	7	07	
081	-	-45	
082	RTN	24	
083	*LBLE	21 15	Englemann spruce equation
084	1	01	
085	.	-62	
086	9	09	
087	2	02	
088	x	-35	
089	1	01	
090	8	08	
091	.	-62	
092	4	04	
093	-	-45	
094	RTN	24	
095	R/S	51	
100			
110			

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Standing and Running Skyline Loadcarrying Capability

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

Given L, h, d, y, ω_1,ω_3 and the tension in the haulback or skyline at the left anchor, $T_1{}^a$, this program computes the horizontal componenet of tension in the haulback or skyline to the right of the carriage

$$H_2 = \frac{\omega_1(L-d)}{2(1+t_3{}^2)^{\frac{1}{2}}}\left\{t_3 + \left[4\left(\frac{T_1{}^a}{\omega_1(L-d)} - \frac{y}{(L-d)}\right)^2 - 1\right]^{\frac{1}{2}}\right\}$$

where t_3 = y-h/L-d and, to be used below, t_1 = y/d. Once H has been computed, the load is determined from the relationship.

$$W_G = 2H_2(t_1+t_3) - \tfrac{1}{2}(R_1+2R_2+R_3) \text{ (to calculate tension in haulback)}$$
$$W_G = H_2(t_1+t_3) - \tfrac{1}{2}(R_1+R_2+R_3) \text{ (to calculate tension in skyline)}$$

where the R's are line segment weights approximated by the expressions

$$R_1 = \omega_1 d(1+t_1{}^2)^{\frac{1}{2}}$$

$$R_2 = \omega_1(L-d)(1+t_3{}^2)^{\frac{1}{2}}$$

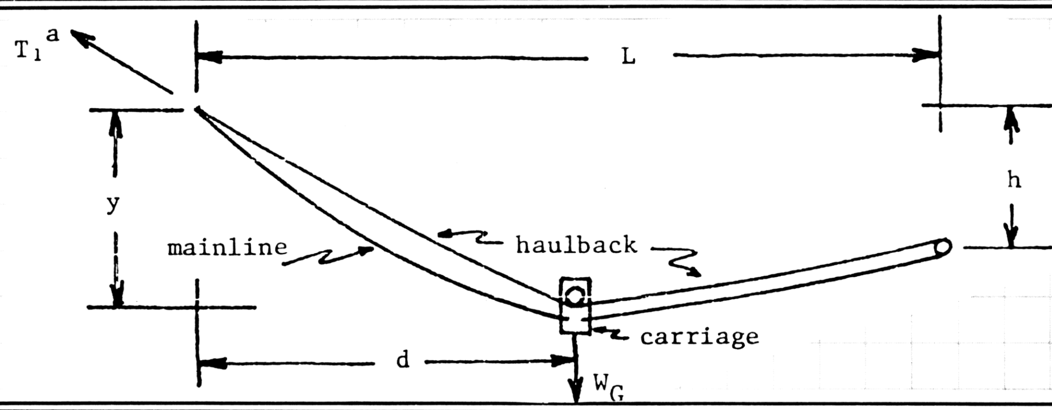
and $$R_3 = \omega_3 d(1+t_1{}^2)^{\frac{1}{2}}$$

Operating Limits and Warnings The matematical description of this skyline assumes that the integrated weight of cable segments in the system can be approximated as expressed above. This depends upon the line segments being tensioned to near their safe working load of one third the ultimate strength. If cables sag, this assumption is violated and the result will be in error.

The user should recognize also that the mainline of this system could be composed of both a mainline and a slack or operating line. In such a case the effect of both lines can be accounted for by entering their combined weight as ω_3.

Program Description II

Sketch(es)



Sample Problem(s)

1.	L,	skyline span	2000 feet
	h,	anchor elevation separation	1000 feet
	d,	carriage horizontal location	1400 feet
	y,	carriage elevation separation	850 feet
	ω_3,	mainline weight per unit length	1.44 pounds/foot
	ω_1,	haulback weight per unit length	1.04 pounds/foot
	$T_1{}^a$,	haulback tension at left anchor	2000 pounds

Solution(s)

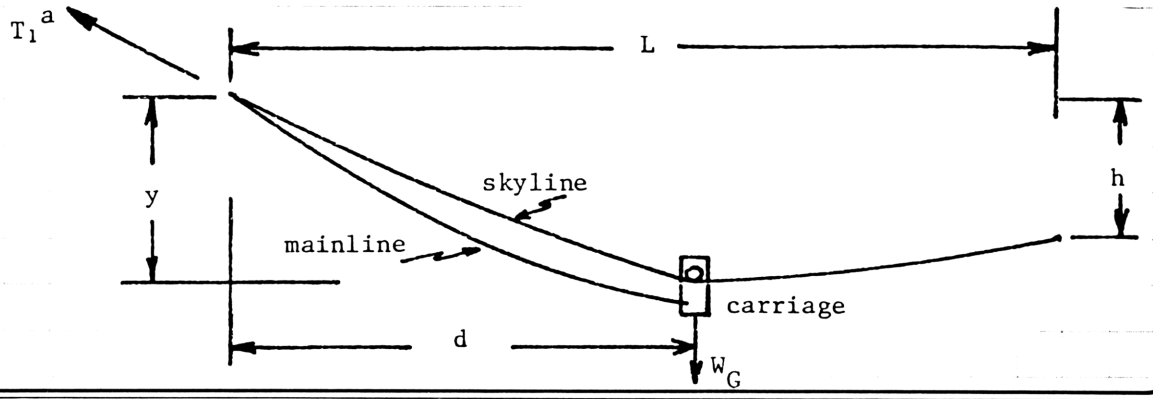
1. 2000[ENTER↑] 1000[A] 1400[B] 850[C]
   1.44[ENTER↑] 1.04[D] 20000[E] ---------------> 10516.67 pounds

Reference(s) Carson, W.W. 1976. Determination of skyline load capability with a programmable pocket calculator. USDA For. Serv. Res. Note. Pac. Northwest For. & Range Exp. Stn., Portland, Oregon.

This program is a modification of the HP-65 Users' Library programs #2351B & 2352B submitted by Ward W. Carson.

Program Description II

Sketch(es)



Sample Problem(s)

2.	L,	skyline span	1000 meters
	h,	anchor elevation separation	300 meters
	d,	carraige horizontal location	400 meters
	y,	carriage elevation separation	200 meters
	ω_3,	mainline weight per unit length	25 Newtons/m
	ω_1,	skyline weight per unit length	40 Newtons/m
	T_1^a,	skyline tension at left anchor	225000 Newtons

Solution(s)

2. [f] [A]

1000[ENTER↑] 300[A] 400[B] 200[C]

25[ENTER↑] 40[D] 225000[E] ----------------> 43882.42 Newtons

Reference(s)

User Instructions

STANDING & RUNNING SKYLINE				
Sky?				
$L \uparrow h$	d	y	ω_3, ω_1	$T_1^a \rightarrow W_G$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1				
2.	If skyline weight and tension is known, press:		f	A	0.00
3.	Key in the following:				
	L	L	↑		
	h	h	A		h/L
	d	d	B		d
	y	y	C		y-h/L-d
	ω_3	ω_3	↑		
	ω_1	ω_1	D		*
4.	Key in T_1^a (tension) at left anchor and compute gross load, W_G	T_1^a	E		W_G
5.	For new case, go to step 2				
*	$\frac{1}{2}(R_1+2R_2+R_3)$ or				
	$\frac{1}{2}(R_1+R_2+R_3)$				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter L and h
002	STO2	35 02	
003	X⇄Y	-41	
004	STO1	35 01	
005	÷	-24	h/L
006	RTN	24	
007	*LBLB	21 12	
008	STO3	35 03	Enter d
009	RTN	24	
010	*LBLC	21 13	
011	STO4	35 04	Enter y
012	RCL3	36 03	
013	÷	-24	$t_1 = y/d$
014	STO5	35 05	
015	RCL4	36 04	
016	RCL2	36 02	
017	-	-45	
018	RCL1	36 01	
019	RCL3	36 03	
020	-	-45	
021	÷	-24	$t_3 = {}^{y-h}/_{L-d}$
022	STO6	35 06	
023	RTN	24	
024	*LBLD	21 14	
025	+	-55	Enter ω_3 and ω_1
026	LSTX	16-63	
027	RCL1	36 01	
028	RCL3	36 03	
029	-	-45	
030	×	-35	$\omega_1(L-d)$
031	STO7	35 07	
032	RCL5	36 05	
033	1	01	
034	→P	34	
035	R↑	16-31	
036	×	-35	
037	RCL3	36 03	R_1+R_3
038	×	-35	
039	F1?	16 23 01	
040	GTO0	22 00	
041	2	02	
042	÷	-24	
043	*LBL0	21 00	
044	RCL6	36 06	
045	1	01	
046	→P	34	
047	RCL7	36 07	R_2
048	×	-35	
049	R↑	16-31	
050	+	-55	
051	F1?	16 23 01	$\frac{1}{2}(R_1+2R_2+R_3)$ or
052	GSB1	23 01	$\frac{1}{2}(R_1+R_2+R_3)$
053	STO8	35 08	
054	RTN	24	
055	*LBLE	21 15	Enter $T_1{}^a$
056	RCL7	36 07	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	÷	-24	
058	RCL4	36 04	
059	RCL1	36 01	
060	RCL3	36 03	
061	-	-45	
062	÷	-24	
063	-	-45	$(T/\omega_1(L-d)-y/(L-d))$
064	X²	53	
065	4	04	
066	×	-35	
067	1	01	
068	-	-45	
069	√X	54	
070	RCL6	36 06	
071	+	-55	
072	RCL7	36 07	
073	×	-35	
074	RCL6	36 06	
075	1	01	
076	→P	34	
077	X⇄Y	-41	
078	R↓	-31	
079	÷	-24	$2H_2$
080	RCL5	36 05	
081	RCL6	36 06	
082	+	-55	
083	×	-35	
084	F1?	16 23 01	
085	GSB1	23 01	
086	RCL8	36 08	W_G
087	-	-45	
088	STO9	35 09	
089	CF1	16 22 01	
090	RTN	24	
091	*LBL1	21 01	
092	2	02	
093	÷	-24	
094	RTN	24	
095	*LBLa	21 16 11	
096	SF1	16 21 01	
097	0	00	
098	RTN	24	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	

REGISTERS

0	1	2	3	4	5	6	7	8	9
	L	h	d	y	t_1	t_3	$\omega_1(L-d)$	Used	W_G

Program Description I

Program Title Latitude & longitude from Geological Survey Map

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables Latitude of a position is determined by scaling distance in inches or cm from a known latitude on a small scale Geological Survey Map to the unknown position. The relationship between the length in meters to the unit of arc is first determined by the following formula:

$$M = 111132.09 - 566.05 \cos 2L + 1.20 \cos 4L - 0.002 \cos 6L + \ldots.$$

where M = length of 1° of the meridian & L is the latitude

and then fractionalized to the surface distance as measured and interpreted by the map scale.

Likewise, the longitude of a position is determined by scaling distance in decimal inches or centimeters from a known longitude along a reference parallel on a small scale Geological Survey Map.

The relationship between the length in meters to the unit of arc along the reference latitude is first determined by the following formula:

$$P = 111415.3 \cos L - 94.55 \cos 3L + .012 \cos 5L - \ldots$$

where L = the latitude and

P = the length of 1° of the parallel (longitude)

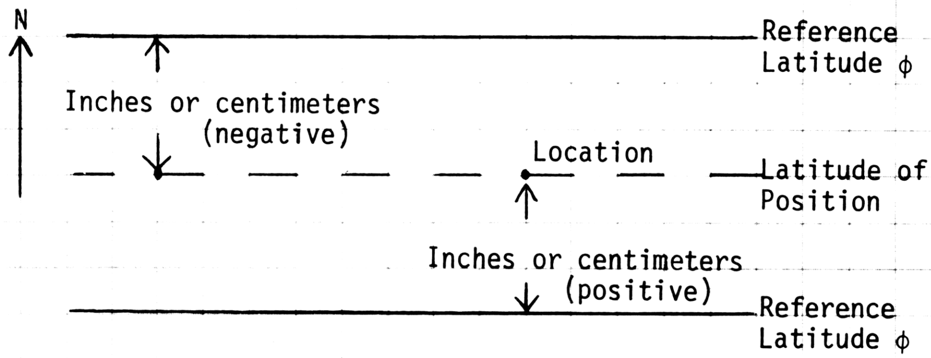
and then fractionalized to the surface distance as measured and interpreted by the map scale.

The latitude of position is used for reference and is the parallel along which the measurement is made.

OPERATING LIMITS AND WARNINGS

Program Description II

Sketch(es)



Sample Problem(s) Latitude:

I. Reference ϕ 56-40' N
Scale: 1: 100,000
Measurement: 9.28 cm (Measuring North)
FROM Geodaetisk Institute Map. Thisted, Danmark (Jutland)

II. Reference ϕ 41°-32'-30" N
Scale: 1: 24,000
Measurement: -7.58 inches (Measuring South)
FROM U.S. Geological Survey Map. Meriden, Ct Quadrangle

Solution(s)

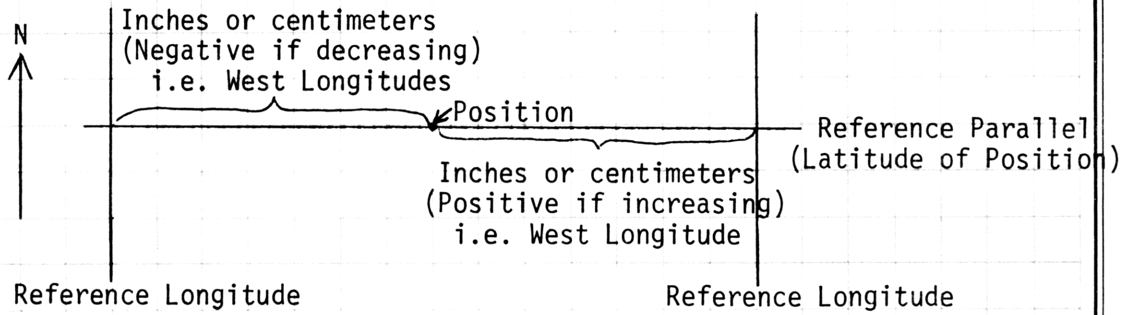
Reference(s)

Bowditch, American Practical Navigator, p. 1187 (1962), H.O.Pub. No. 9.

This is a translation of the HP-65 Users' Library program #04777A & # 4787A submitted by Sid M. Miller.

Program Description II

Sketch(es)



Sample Problem(s) Longitude:

III. Reference φ 56° - 37' N

Scale: 1: 100,000 — FROM Geodaetisk Institute Map Thisted, Danmark (Jutland)

Measurement: - 10.23 cm (measuring West)

Reference λ : 8° - 40' E

IV. Reference φ 41° - 30' N

Scale: 1: 24,000 — FROM U.S. Geological Survey Map Meriden, Ct. Quadrangle

Measurement: 5.7 inches (measuring West)

Reference λ : 72° - 45' W

NOTE: As the map scale gets larger, the seconds computation becomes less significant. Measurements may be made more handily buy using an engineer's scale marked in decimal inches. Inches may be more readily measured with precision by using the 5:1 scale and dividing by 5.

Solution(s)

1. 56.4[A] 100000[B] 9.28[D] [E] ------------> 56° 45' 00"
   [RCL] [4] --------------------------------> 111355.4656 meters per 1° latitude
2. 41.3230[A] 24000[B] 7.58[CHS] [C] [E] ----> 41° 30' 00"
   [RCL] [4] --------------------------------> 111062.7586 meters per 1° latitude
3. 56.37[A] 100000[B] 10.23[CHS] [D] 8.40[f][E]--->8° 30' 00" E
   [RCL] [4] --------------------------------> 61397.8967 meters per 1° longitude
4. 41.30[A] 24000[B] 5.7[C] 72.45[f][E] ---------->72° 47' 30" W
   [RCL] [4] -------------------------------------->83498.5421 meters per 1° longitude

Reference(s)

User Instructions

LATITUDE AND LONGITUDE FROM GEOL. SURVEY MAP

1 | Ref ϕ | Scale | Inch | cm | Ref. L → Long. / → Lat. | 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1 and side 2				
2.	Input reference latitude				
	(i.e. latitude of position)	D.MS	A		D.d
3.	Input map scale				
	(ratio 1:XXXX)	XXXX	B		XXXX
4.	For Latitude:				
	Input distance measured on map from				
	reference latitude to unknown position.				
	Negative if south of reference. Positive if				
	North of reference.				
	INCHES as decimal (North)	INCH	C		cm x 10^{-2}
	INCHES as decimal (South)	INCH	CHS	C	-cm x 10^{-2}
	-or-				
	CM (North)	cm	D		cm x 10^{-2}
	CM (South)	cm	CHS	D	-cm x 10^{-2}
	Compute. Output is position		E		D.MS
5.	For Longitude:				
	Input distance measured on map along reference				
	parallel between reference longitude and				
	position.				
	INCHES as decimal (increasing)	INCH	C		cm x 10^{-2}
	INCHES as decimal (decreasing)	INCH	CHS	C	-cm x 10^{-2}
	-or-				
	CM (increasing)		D		cm x 10^{-2}
	CM (decreasing)		CHS	D	-cm x 10^{-2}
6.	To recall meters per 1° latitude or longitude		RCL	4	Meters

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	HMS→	16 36	Input φ reference
003	STO1	35 01	
004	RTN	24	
005	*LBLB	21 12	
006	STO2	35 02	Input map scale
007	RTN	24	
008	*LBLC	21 13	Convert to cm x 10^{-2}
009	2	02	
010	.	-62	
011	5	05	
012	4	04	
013	x	-35	
014	*LBLD	21 14	
015	EEX	-23	Convert cm to meters
016	2	02	
017	CHS	-22	
018	x	-35	
019	STO3	35 03	
020	RTN	24	
021	*LBLE	21 15	
022	1	01	Compute meters per
023	1	01	1° Lat. at the
024	1	01	reference φ
025	1	01	
026	3	03	
027	2	02	
028	.	-62	
029	0	00	
030	9	09	
031	ENT↑	-21	
032	5	05	
033	6	06	
034	6	06	
035	.	-62	
036	0	00	
037	5	05	
038	RCL1	36 01	
039	2	02	
040	x	-35	
041	COS	42	
042	x	-35	
043	-	-45	
044	RCL1	36 01	
045	4	04	
046	x	-35	
047	COS	42	
048	1	01	
049	.	-62	
050	2	02	
051	x	-35	
052	+	-55	
053	RCL1	36 01	
054	6	06	
055	x	-35	
056	COS	42	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	.	-62	
058	0	00	
059	0	00	
060	2	02	
061	x	-35	
062	-	-45	
063	STO4	35 04	
064	RCL3	36 03	
065	RCL2	36 02	Distance from
066	x	-35	reference φ
067	X⇄Y	-41	Degrees from
068	÷	-24	φ reference
069	RCL1	36 01	Add/subt. to de-
070	+	-55	termine position
071	→HMS	16 35	
072	RTN	24	
073	*LBLe	21 16 15	
074	HMS→	16 36	Compute meters per
075	STO5	35 05	1° longitude at
076	1	01	the reference
077	1	01	parallel
078	1	01	
079	4	04	
080	1	01	
081	5	05	
082	.	-62	
083	1	01	
084	3	03	
085	RCL1	36 01	
086	COS	42	
087	x	-35	
088	9	09	
089	4	04	
090	.	-62	
091	5	05	
092	5	05	
093	RCL1	36 01	
094	3	03	
095	x	-35	
096	COS	42	
097	x	-35	
098	-	-45	
099	.	-62	
100	0	00	
101	1	01	
102	2	02	
103	RCL1	36 01	
104	5	05	
105	x	-35	
106	COS	42	
107	x	-35	
108	+	-55	
109	STO4	35 04	
110	RCL3	36 03	Dist. from ref.
111	RCL2	36 02	Longitude
112	x	-35	

REGISTERS

0	1 Ref. φ	2 Scale	3 Used	4 Meter/1°	5	6	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	X⇄Y	-41	
114	÷	-24	
115	RCL5	36 05	Add/subtract to det. position
116	+	-55	
117	→HMS	16 35	
118	RTN	24	
119	R/S	51	

LABELS

A	B	C	D	E
Ref. ϕ	Scale	Inches	Cm	→ Lat.
a	b	c	d	e → Long.
0	1	2	3	4
5	6	7	8	9

FLAGS

0	
1	
2	
3	

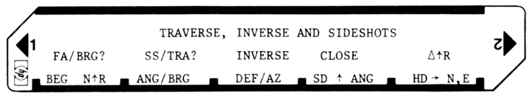
SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	4

TRAVERSE, INVERSE AND SIDESHOTS



This program is designed for reducing field data and solving some of the commonly encountered field traversing problems. Four major routines are provided: 1) Bearing/Azimuth Traverse, 2) Field Angle Traverse, 3) Inverse, and 4) Sideshots. These routines can be used separately, but it is possible at any time to switch from one to another as required. Three additional routines are provided to supplement the four major routines: 5) Slope Distance Reduction, 6) Closure For Traverses, and 7) Curved Sides For Traverses. Each of the seven routines is described individually below, with separate user instructions.

This program uses two mode "switches", labelled on the card as "FA/BRG?" and "SS/TRA?" Each switch "toggles" between zero and one (or one and zero) with each push of the keys (f and A or f and B), allowing you to define four different modes:

Mode	FA/BRG? f A	SS/TRA? f B
Bearing/azimuth angle traverse (BRG-TRA)	1.0000	1.0000
Field angle traverse (FA-TRA)	0.0000	1.0000
Field angle sideshots (FA-SS)	0.0000	0.0000
Bearing/azimuth angle sideshots (BRG-SS)	1.0000	0.0000

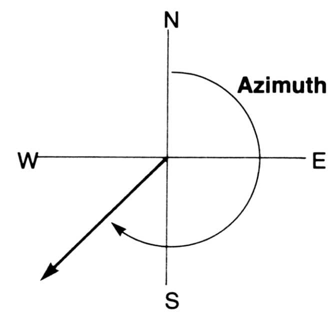
As the table shows, a display of 0.0000 after pushing f and A means the calculator is expecting field angle (FA) input. Similarly, a display of 1.0000 after pushing f and A indicates bearing or azimuth angle input (BRG).

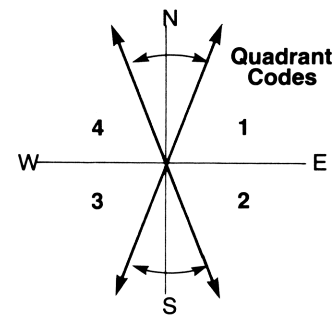
The instructions generally call for the selection of angle input to be made at the beginning of the program and left unchanged, but it can be changed at any time if desired. In switching from BRG to FA mode, the last azimuth that was input becomes the reference direction from which the field angles are turned.

The table also shows that a display of 0.0000 after pushing f and B means sideshots (SS), while a display of 1.0000 after pushing f and B means traverse. For sideshots, the transit remains stationary during several shots, while during a traverse, the transit is moved to the next point after each shot. As with FA/BRG angle modes, switching between SS and TRA modes can be done at any time.

Bearing/Azimuth Traverse

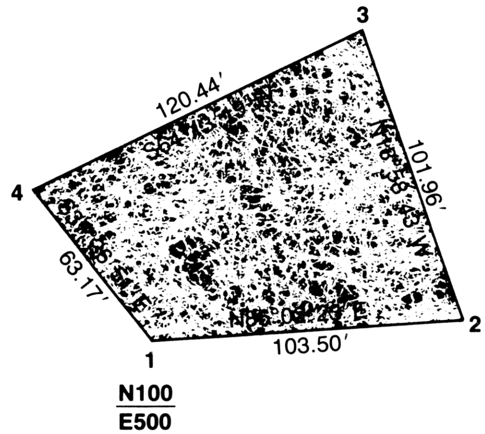
This routine uses quadrant bearings or azimuths and horizontal distances to compute the coordinates of successive points in a traverse. The routines for Slope Distance Reduction and Curved Sides for Traverses can be used where slope distances or curves are encountered. At the end of the traverse, Closure for Traverses can be used to get the total distance traversed, area, and error of closure. Angle conventions for azimuths and quadrant bearings are shown below:





STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select bearing traverse by			
	pressing f A, f B.		f A	1.0000*
			f B	1.0000*
3	Input beginning coordinates.	BEG N	ENTER↑	
		BEG E	A	1, N, E
4	Input bearing	BRG (D.MS)	ENTER↑	
	and quadrant code	QD	B	AZ(D.MS)
	or			
	azimuth.	AZ(D.MS)	C	AZ(D.MS)
5	Input horizontal distance and			
	compute coordinates.	HD	E	HD, Point,
				N. E
6	Repeat steps 4 and 5 for			
	successive courses.			
	*If you don't get the output			
	shown, repeat the step.			

Example:



Starting with point 1 with coordinates N100, E500, traverse the figure above and compute the coordinates of the other points.

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
[f] [A] →	1.0000*
[f] [B] →	1.0000*
100 [ENTER↑] 500 [A] →	1.0000 *** Point
	100.0000 *** N
	500.0000 *** E
86.0223 [ENTER↑] 1 [B] →	86.0223 *** AZ
103.5 [E] →	103.5000 *** HD
	2.0000 *** Point
	107.1482 *** N
	603.2529 *** E
18.5843 [ENTER↑] 4 [B] →	341.0117 *** AZ
101.96 [E] →	101.9600 *** HD
	3.0000 *** Point
	203.5657 *** N
	570.0939 *** E

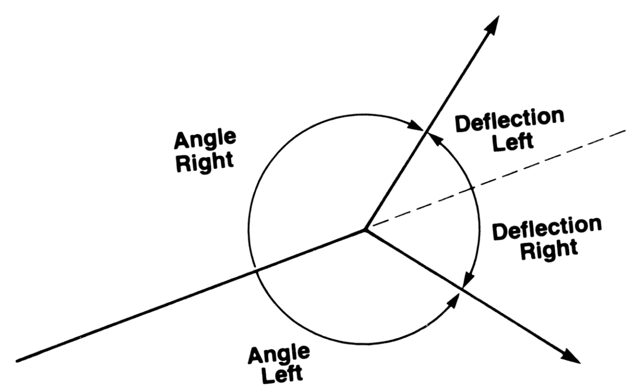
*If you don't get the output shown, repeat the step.

64.1319 [ENTER↑] 3 [B] →	244.1319 *** AZ
120.44 [E] →	120.4400 *** HD
	4.0000 *** Point
	151.1880 *** N
	461.6395 *** E
37.2651 [ENTER↑] 2 [B] →	142.3309 *** AZ
63.17 [E] →	63.1700 *** HD
	5.0000 *** Point
	101.0366 *** N
	500.0490 *** E

To avoid reworking this example, you might wish to work next the Closure for Traverse example on page 01-16.

Field Angle Traverse

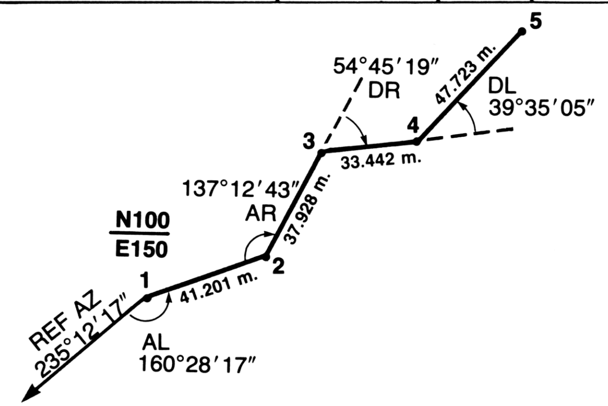
This routine uses horizontal distances and angles or deflections turned from a reference azimuth to compute the coordinates of successive points in a traverse. The routines for Slope Distance Reduction and Curved Sides for Traverses can be used where slope distances or curves are encountered. At the end of the traverse, Closure for Traverses can be used to get the total distance traversed, area, and error of closure. Angle conventions are shown below:



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select field angle traverse by			
	pressing f A, f B.		f A	0.0000*
			f B	1.0000*
3	Input beginning coordinates.	BEG N	ENTER↑	
		BEG E	A	1, N, E
4	Input reference azimuth †:			
	away from beginning point	REF AZ(D.MS)	B	AZ(D.MS)
	or			
	toward beginning point.	REF AZ(D.MS)	C	AZ(D.MS)
	†A reference bearing toward			
	the point may be used in place			
	of an azimuth:			
4′	Select bearing input by			
	pressing f A.		f A	1.0000*
	Input reference bearing toward			
	beginning point	REF BRG(D.MS)	ENTER↑	
	and quadrant			
	code.	QD	B	AZ(D.MS)
	Select field angle traverse by			
	pressing f A.		f A	0.0000*
	Go to step 5.			
	*If you don't get the output			
	shown, repeat the step.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
5	Input field angle:			
	angle right	AR(D.MS)	B	AZ(D.MS)
	or			
	angle left	AL(D.MS)	CHS B	AZ(D.MS)
	or			
	deflection right	DR(D.MS)	C	AZ(D.MS)
	or			
	deflection left	DL(D.MS)	CHS C	AZ(D.MS)
6	Input horizontal distance and			
	compute coordinates.	HD	E	HD, Point,
				N, E
7	Repeat steps 5 and 6 for			
	successive courses.			

Example:



Starting with point 1 with coordinates N100, E150, traverse the figure above and compute the coordinates of the other points.

Keystrokes:	Outputs:
Load side 1 and side 2 .	
f A ⟶	0.0000*
f B ⟶	1.0000*
100 ENTER↑ 150 A ⟶	1.0000 *** Point
	100.0000 *** N
	150.0000 *** E

*If you don't get the output shown, repeat the step.

235.1217 B	→	55.1217 *** Ref AZ
160.2817 CHS B	→	74.4360 *** AZ
(NOTE: 74°43′60″ = 74°44′00″)		
41.201 E	→	41.2010 *** HD
		2.0000 *** Point
		110.8487 *** N
		189.7470 *** E
137.1243 B	→	31.5643 *** AZ
37.928 E	→	37.9280 *** HD
		3.0000 *** Point
		143.0327 *** N
		209.8151 *** E
54.4519 C	→	86.4202 *** AZ
33.442 E	→	33.4420 *** HD
		4.0000 *** Point
		144.9574 *** N
		243.2017 *** E
39.3505 CHS C	→	47.0657 *** AZ
47.723 E	→	47.7230 *** HD
		5.0000 *** Point
		177.4338 *** N
		278.1698 *** E

This example could also have been worked by using a reference bearing, as shown below. An azimuth of 235°12′17″ is the same as a bearing of S55°12′17″W. Since the instructions (step 4′) call for a reference bearing toward the beginning point, the bearing is input as N55°12′17″E.

Keystrokes:		**Outputs:**
f A	→	0.0000*
f B	→	1.0000*
100 ENTER↑ 150 A	→	1.0000 *** Point
		100.0000 *** N
		150.0000 *** E
Select BRG mode to input reference bearing:		
f A	→	1.0000*
55.1217 ENTER↑ 1 B	→	55.1217 *** Ref AZ
f A	→	0.0000*
160.2817 CHS B	→	74.4400 *** AZ

*If you don't get the output shown, repeat this step.

41.201 E	→	41.2010 *** HD
		2.0000 *** Point
		110.8487 *** N
		189.7470 *** E

etc.

Inverse

This routine calculates the distance and azimuth of the line joining two points, given the coordinates of the points. A figure may be traversed by entering the coordinates of successive points as in the example. The routines for Slope Distance Reduction and Curved Sides for Traverses may be used where slope distances or curves are encountered. At the end of a traverse, Closure for Traverses can be used to get the total distance traversed and area.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select traverse by pressing			
	f B.		f B	1.0000*
3	Input beginning coordinates.	BEG N	ENTER↑	
		BEG E	A	1, N, E
4	Input coordinates of next point			
	and compute azimuth and			
	horizontal distance for course.			
	Point number, and coordinates			
	of point input are also output,			
	but HD and AZ are left in the x			
	and y registers.	N	ENTER↑	
		E	f C	AZ(D.MS),HD;
				Point, N, E
5	Repeat step 4 for successive			
	courses or go to step 3 for a			
	new starting point.			
	*If you don't get the output			
	shown, repeat the step.			

Example:

Work the Field Angle Traverse example as an inverse. Input the coordinates of the points and calculate the azimuth and distance of the line joining each pair of points.

Keystrokes:	Outputs:
Load side 1 and side 2	
f B →	1.0000*
100 ENTER↑ 150 A →	1.0000 *** Point 100.0000 *** N 150.0000 *** E
110.8487 ENTER↑ 189.7470 f C →	74.4360 *** AZ 41.2010 *** HD 2.0000 *** Point 110.8487 *** N 189.7470 *** E
143.0327 ENTER↑ 209.8151 f C →	31.5643 *** AZ 37.9281 *** HD† 3.0000 *** Point 143.0327 *** N 209.8151 *** E

†The distance in the original example was 37.9280. The discrepancy is caused by inputting the coordinates as 4 decimal place numbers (rounding to 4 places). These points were calculated to 10 decimal places when running the Field Angle Traverse example.

Keystrokes:	Outputs:
144.9574 ENTER↑ 243.2017 f C →	86.4202 *** AZ 33.4420 *** HD 4.0000 *** Point 144.9574 *** N 243.2017 *** E
177.4338 ENTER↑ 278.1698 f C →	47.0657 *** AZ 47.7230 *** HD 5.0000 *** Point 177.4338 *** N 278.1698 *** E

*If you do not get this output, repeat this step.

Sideshots

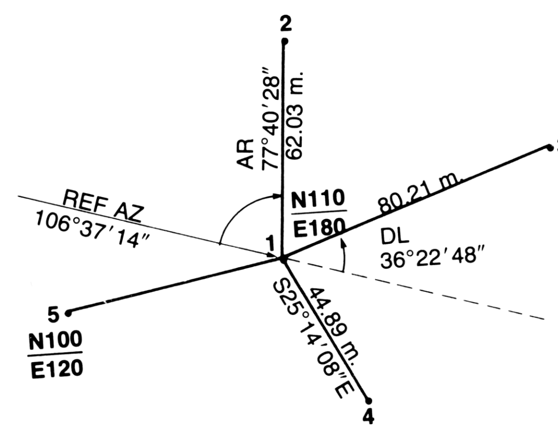
This routine is used to make sideshots or radials from a point. Any of three methods may be used for a sideshot, 1) input a distance and a field angle turned from a reference azimuth and calculate the coordinates of the point, 2) input a distance and a bearing and calculate the coordinate of a point, 3) input the coordinates of a point and calculate the distance and azimuth of the line to the point. The Slope Distance Reduction routine may be used where slope distances are encountered.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Input beginning coordinates.	BEG N	ENTER↑	
		BEG E	A	Point,
				N, E
	To use field angles, go to step			
	3; to use bearings, go to step 9;			
	to inverse from coordinates,			
	go to step 13.			
3	Select bearing traverse by			
	pressing f A, f B.		f A	1.0000*
			f B	1.0000*
4	Input			
	reference azimuth to point	REF AZ(D.MS)	C	AZ(D.MS)
	or			
	input reference bearing to	BRG(D.MS)	ENTER↑	
	point and quadrant code	QD	B	(AZ(D.MS)
5	Select field angle sideshots by			
	pressing f A, f B.		f A	0.0000*
			f B	0.0000*
	*If you don't get the output			
	shown, repeat the step.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
6	Input field angle:			
	angle right	AR(D.MS)	B	AZ(D.MS)
	or			
	angle left	AL(D.MS)	CHS B	AZ(D.MS)
	or			
	deflection right	DR(D.MS)	C	AZ(D.MS)
	or			
	deflection left	DL(D.MS)	CHS C	AZ(D.MS)
7	Input horizontal distance.	HD	E	HD, Point,
				N. E
8	Repeat steps 6 and 7 for			
	successive field angle shots.			
9	Select bearing/azimuth side-			
	shots by pressing f A,		f A	1.0000*
	f B.		f B	0.0000*
10	Input azimuth	AZ(D.MS)	C	AZ(D.MS)
	or			
	input bearing	BRG(D.MS)	ENTER↑	
	and quadrant code	QD	B	AZ(D.MS)
11	Input horizontal distance.	HD	E	HD, Point,
				N, E
12	Repeat steps 10 and 11 for			
	successive bearing/azmuth			
	shots.			
13	Select sideshots by pressing			
	f B.		f B	0.0000*
14	Input coordinates of next point.	N	ENTER↑	
		E	f C	AZ(D.MS), HD
				Point, N, E
	*If you don't get the output			
	shown, repeat the step.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
15	Repeat line 14 for successive			
	shots.			

Example:



Starting from point 1 with coordinates N110, E180, calculate the sideshots shown in the figure above.

Keystrokes:	Outputs:
Load side 1 and side 2.	
110 ENTER↑ 180 A ⟶	1.0000 *** Point
	110.0000 *** N
	180.0000 *** E

Select BRG and TRA modes to input reference azimuth:

```
f A ——————→          1.0000*
f B ——————→          1.0000*
106.3714 C ——→     106.3714 *** Ref AZ
```

Now, select FA and SS modes

```
f A ——————→          0.0000*
f B ——————→          0.0000*
77.4028 B ——→        4.1742 *** AZ
62.03 E ———→        62.0300 *** HD
                     2.0000 *** Point
                   171.8558 *** N
                   184.6455 *** E
36.2248 CHS C ——→   70.1426 *** AZ
80.21 E ———→        80.2100 *** HD
                     3.0000 *** Point
                   137.1167 *** N
                   255.4873 *** E
```

Select BRG mode

```
f A ——————→          1.0000*
```

(NOTE: It is not necessary to press f B since the calculator is still set for sideshots.)

```
25.1408 ENTER↑ 2 B ——→   154.4552 *** AZ
44.89 E ————→             44.8900 *** HD
                           4.0000 *** Point
                          69.3942 *** N
                         199.1384 *** E
```

(NOTE: Again, it is not necessary to press f B since the calculator is still set for sideshots.)

```
100 ENTER↑ 120 f C ——→   260.3216 *** AZ
                          60.8276 *** HD
                           5.0000 *** Point
                         100.0000 *** N
                         120.0000 *** E
```

*If you don't get the output shown, repeat the step.

Slope Distance Reduction

This routine calculates the horizontal distance and elevation change given the slope distance and a vertical angle or zenith angle. Vertical angles must be less than 45° and zenith angles must be greater than 45°.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Input slope distance,	SD	ENTER↑	
	and vertical or zenith angle.	VA/ZA(D.MS)	D	Ang(D.MS),
				SD,HD
3	Read elevation change.		x⇄y	ΔEL

Example:

Mr. D. Thomas, a bit of a skeptic when it comes to new fangled electronic instruments, was using a theodolite and chain to check out his new HP-3810 total station. The slope distance he measured of 104.74 feet checked out with the reading on the 3810. His theodolite showed a zenith angle of 87°52′37″. Are the horizontal distance of 104.668 feet and the change in elevation of 3.880 feet indicated by the 3810 correct?

Keystrokes:	Outputs:
104.74 ENTER↑ 87.5237 D ——→	87.5237 *** ZA
	104.7400 *** SD
	104.6681 *** HD
x⇄y ——→	3.8802 Δ EL

It looks like Mr. Thomas can put away his theodolite for awhile.

Closure for Traverses

This routine is designed to be used at the completion of a Field Angle Traverse, Bearing/Azimuth Traverse, or Inverse. From the correct closing coordinates, the following are calculated: total distance traversed (Σ HD), area, error azimuth, and error distance. The traverse can be closed exactly by inversing from the last point calculated to the correct closing coordinates.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Input correct closing			
	coordinates	N	ENTER↑	
		E	f D	Σ HD
				Area,*
				Error azimuth,
				Error distance,
				Point
				N, E
2	To include the error course in			
	the traverse and adjust the			
	area, input the correct closing			
	coordinates and inverse	N	ENTER↑	
		E	f C	AZ(D.MS),
				HD; Point, N,E
3	Go to step 1 to recalculate			
	Σ HD and area			
	Note: Step 2 may be performed			
	before step 1, and step 3 may be			
	omitted if desired.			
	*For area in acres:	area(ft.^{2})	ENTER↑	area(ft.^{2})
			43560	
			÷	Area(acres)

Example:

Rework the example for the Bearing/Azimuth Traverse routine and then use the Closure for Traverses.

Keystrokes:	**Outputs:**
The last coordinates computed will be →	5.0000 *** Point
	101.0366 *** N
	500.0490 *** E
100 ENTER↑ 500 f D →	389.0700 *** Σ HD
	8855.4922 *** Area
	182.4219 *** Error AZ
	1.0378 *** Error Dist
	6.0000 *** Point
	100.0000 *** N
	500.0000 *** E

An error of over a foot in 389 feet would be unacceptable in many cases and forcing the traverse to close exactly would not be the solution; but an indication of the effect on area can at least be found this way.

(NOTE: Coordinates do not have to be keyed in, since they should be left from the calculations above.)

f C →	182.4219 *** AZ
	1.0378 *** HD
	7.0000 *** Point
	100.0000 *** N
	500.0000 *** E

(NOTE: Pressing R↓ R↓ now will bring the closing coordinates back for closure calculations.)

R↓ R↓ →	500.0000 E
f D →	390.1078 *** Σ HD
	8855.4668 *** Area
	270.0000 *** Error AZ
	2.450000000–09 *** Error Dist
	8.0000 *** Point
	100.0000 *** N
	500.0000 *** E

The error distance is now on the order of 10^{-9} or essentially zero. The new area calculation is only about .03 square feet different. The final area in acres can be found as follows:

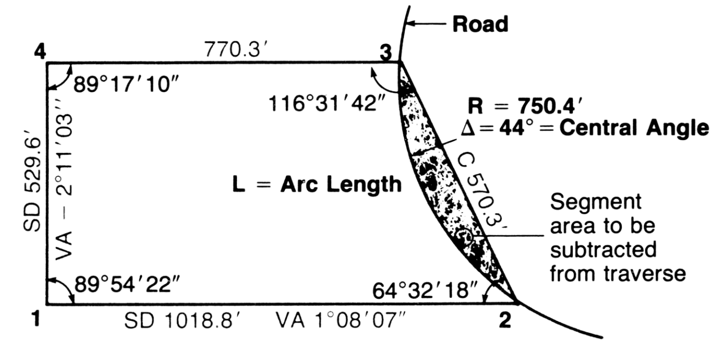
8855 ENTER↑ 43560 ÷ ——→ 0.2033 Area

Curved Sides for Traverses

This routine is designed to be used with the Field Angle Traverse, Bearing/Azimuth Traverse and Inverse routines to include a circular curved side. After traversing or inversing along the chord from the beginning point of the curve (PC) to the end point of the curve (PT), the central angle and radius are input. The segment area and arc length are calculated for use in the Closure for Traverses routine to calculate distance traversed and area. If the central angle or the radius are not known, they may be calculated using the Curve Solutions program. But, be sure to reset the proper traverse mode using f A, f B when you return from Curve Solutions before proceeding with Traverse, Inverse and Sideshots.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Traverse along the chord from			
	the beginning point of the curve			
	(PC) to the end point of the			
	curve (PT) just as you would for			
	any course in the traverse.			
	Then before proceeding with			
	traverse, perform step 2			
	below.			
2	Input central angle	Δ(D.MS)	ENTER↑	
	and radius (positive if			
	segment area is to be added			
	to traverse, negative if			
	segment area is to be sub-			
	tracted from traverse).	R	f E	Segment area,
				Chord,
				Arc length,
				Δ,
				Radius

Example:



The purchase of a piece of property is being considered, but there is some question as to the exact size as it is bordered by a road on one end. The sketch above shows a rough survey, what is the correct area?

Keystrokes: **Outputs:**

This problem can be solved as a field angle traverse.

f A ——→ 0.0000*

f B ——→ 1.0000*

Arbitrarily make point 1 NO, EO.

0 ENTER↑ 0 A ——→ 1.0000 *** Point
0.0000 *** N
0.0000 *** E

Use a reference azimuth away from point 1 of 0°.

0 B ——→ 180.0000 *** AZ

89.5422 B ——→ 89.5422 *** AZ

1018.8 ENTER↑ 1.0807 D ——→ 1.0807 *** VA
1018.8000 *** SD

*If you don't get the output shown, repeat this step.

E →	1018.6000 ***	HD
	2.0000 ***	Point
	1.6691 ***	N
	1018.5986 ***	E
64.3218 B →	334.2640 ***	AZ
570.3 E →	570.3000 ***	HD
	3.0000 ***	Point
	516.1752 ***	N
	772.5792 ***	E
44 ENTER↑ 750.4		
CHS f E →	-20633.8201 ***	Seg. area
	570.3000 ***	C
	576.2658 ***	L
	44.0000 ***	Δ
	-750.4000 ***	R
116.3142 B →	270.5822 ***	AZ
770.3 E →	770.3000 ***	HD
	4.0000 ***	Point
	529.2529 ***	N
	2.3902 ***	E
89.1710 B →	180.1532 ***	AZ
529.6 ENTER↑ 2.1103 CHS D →	-2.1103 ***	VA
	529.6000 ***	SD
E →	529.2152 ***	HD
	5.0000 ***	Point
	0.0431 ***	N
	-0.0010 ***	E
0 ENTER↑ 0 f D →	2894.3811 ***	Σ HD
	445437.4280 ***	Area
	178.3656 ***	Error AZ
	0.0431 ***	Error Dist
	6.0000 ***	Point
	0.0000 ***	N
	2.900000000-11 ***	E
445437 ENTER↑ 43560 ÷ →	10.2258	Area

The error of closure is .04 feet and the area is 445,437 square feet or 10.2 acres.

Notes

Appendix B-1
FORMULAS AND REFERENCES

GENERAL REFERENCES:

1. Surveying, Theory and Practice, Fifth Edition, Raymond E. Davis, Francis S. Foote, Joe W. Kelly, McGraw Hill Book Company, New York, 1966.

2. Surveying, Sixth Edition, Francis H. Moffitt and Harry Bouchard, Intex Educational Publishers, New York, 1975.

Program 1—Traverse, Inverse and Sideshots

1. $$\text{Azimuth} = 180\left\{\text{INT}\ \frac{QD}{2} - \text{BRG}\cos\left[(180)(QD)\right]\right\}$$

2. $HD = SD \sin(\text{zenith angle})$

3. $HD = SD \cos(\text{vertical angle})$

4. $\text{Latitude}_k = LAT_k = N_{k+1} - N_k$

   For instance: $LAT_1 = N_2 - N_1$

5. $\text{Departure}_k = DEP_k = E_{k+1} - E_k$

   For instance: $DEP_4 = E_5 - E_4$

6. $$\text{Area} = \sum_{k=1}^{n} LAT_k \left(\frac{1}{2} DEP_k + \sum_{j=1}^{k-1} DEP_j\right)$$

   In evaluating equation 6, j assumes all values from l to k for each value of k, before k takes on the next higher value. For instance, for k = 3, the sum of departures 1 and 2 is added to ½ of departure 3, and the result is multiplied by latitude 3.

   For n = 3, the three terms of equation 6 (for k = 1, 2 and 3) are =

   $$k = 1: LAT_1\left(\frac{1}{2} DEP_1\right)$$

   $$k = 2: LAT_2\left(\frac{1}{2} DEP_2 + DEP_1\right)$$

   $$k = 3: LAT_3\left(\frac{1}{2} DEP_3 + DEP_1 + DEP_2\right)$$

   For n = 3, the area is the sum of these three terms.

7. $$\text{Segment area} = \frac{R^2}{2}\left(\frac{\Delta\pi}{100} - \sin\Delta\right)$$

8. $$\text{Arc length: } L = \frac{R\Delta\pi}{180}$$

   where:

   INT = Integer portion of number (portion to left of decimal point).

   QD = Quadrant.

   BRG = Bearing.

   HD = Horizontal distance.

   SD = Slope distance.

   n = Number of points in survey.

   R = Radius of curve of segment boundary.

   Δ = Central angle of curve of segment boundary.

Program 2—Traverse Adjustment

See reference 1, pp 458-463

Compass Rule for latitude and departure course correction:

9. $$\text{Corrected latitude}_1 = L_1 + \ell_1 = L_1 + \frac{(HD)_1(ER\ L)}{\Sigma(HD)}$$

10. $$\text{Corrected departure}_1 = D_1 + d_1 = D_1 + \frac{(HD)_1(ER\ L)}{\Sigma\,(HD)}$$

    Crandall Rule for latitude and departure course correction:

11. $$A = \frac{(ER\ D)\left[\Sigma\frac{(L)(D)}{(HD)}\right] - (ER\ L)\left[\Sigma\frac{D^2}{(HD)}\right]}{\left[\Sigma\frac{D^2}{(HD)}\right]\left[\Sigma\frac{L^2}{(HD)}\right] - \left[\Sigma\frac{(L)(D)}{(HD)}\right]^2}$$

12. $$B = \frac{(ER\ L)\left[\Sigma\frac{(L)(D)}{(HD)}\right] - (ER\ D)\left[\Sigma\frac{L^2}{(HD)}\right]}{\left[\Sigma\frac{D^2}{(HD)}\right]\left[\Sigma\frac{L^2}{(HD)}\right] - \left[\Sigma\frac{(L)(D)}{(HD)}\right]^2}$$

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	BEG N,E input
002	CLRG	16-53	
003	1	01	Initialize pt. no.
004	STOI	35 46	
005	SPC	16-11	
006	PRTX	-14	
007	R↓	-31	
008	STO8	35 08	BEG E
009	X⇄Y	-41	
010	PRTX	-14	
011	STO7	35 07	BEG N
012	X⇄Y	-41	
013	PRTX	-14	
014	1	01	
015	8	08	180
016	0	00	
017	STO9	35 09	
018	R/S	51	
019	*LBLB	21 12	AR, AL,BRG input
020	F0?	16 23 00	Was bearing input?
021	GTO0	22 00	
022	RCL9	36 09	180
023	HMS+	16-55	DR=AR+180,DL=180--AL
024	*LBLC	21 13	DR,DL,AZ input
025	HMS→	16 36	Was azimuth input?
026	F0?	16 23 00	
027	GTO1	22 01	
028	RCL0	36 00	AZ
029	+	-55	AZ+DR,AZ-DL
030	GTO1	22 01	BRG to AZ
031	*LBL0	21 00	BRG
032	X⇄Y	-41	
033	HMS→	16 36	QD
034	X⇄Y	-41	
035	ENT↑	-21	
036	ENT↑	-21	
037	2	02	
038	÷	-24	INT(QD/2)
039	INT	16 34	
040	RCL9	36 09	180 INT(QD/2)
041	×	-35	
042	X⇄Y	-41	QD
043	RCL9	36 09	
044	×	-35	Cos (180 QD)
045	COS	42	
046	R↑	16-31	
047	×	-35	BRG cos (180 QD)
048	-	-45	AZ
049	*LBL1	21 01	
050	1	01	
051	→R	44	
052	*LBL8	21 08	
053	→P	34	AZ
054	X⇄Y	-41	AZ positive?
055	X>0?	16-44	
056	GTO7	22 07	
057	3	03	
058	6	06	
059	0	00	
060	+	-55	360 + AZ
061	*LBL7	21 07	
062	F1?	16 23 01	Is traverse on?
063	STO0	35 00	
064	STOA	35 11	
065	→HMS	16 35	
066	SPC	16-11	
067	PRTX	-14	AZ
068	RTN	24	
069	*LBLD	21 14	SD to HD
070	SPC	16-11	
071	PRTX	-14	Slope angle
072	HMS→	16 36	
073	X⇄Y	-41	
074	PRTX	-14	SD
075	→R	44	
076	X≤Y?	16-35	x=short side?
077	X⇄Y	-41	
078	R/S	51	
079	*LBLd	21 16 14	Close
080	RCL6	36 06	ΣHD
081	SPC	16-11	
082	SPC	16-11	
083	PRTX	-14	
084	R↓	-31	
085	RCL4	36 04	AREA
086	ABS	16 31	
087	RCL5	36 05	Curve Area
088	+	-55	
089	PRTX	-14	
090	R↓	-31	
091	CF1	16 22 01	Sideshot on
092	GSBc	23 16 13	Inverse to close
093	SF1	16 21 01	Traverse on
094	R↓	-31	
095	R↓	-31	
096	R/S	51	
097	*LBLc	21 16 13	INVERSE
098	RCL8	36 08	BEG E
099	-	-45	
100	RCL3	36 03	DEP
101	-	-45	E-BEG E-DEP
102	X⇄Y	-41	
103	RCL7	36 07	
104	-	-45	BEG N
105	RCL2	36 02	LAT
106	-	-45	N-BEG N-LAT
107	GSB8	23 08	Output AZ
108	HMS→	16 36	
109	X⇄Y	-41	HD
110	GSB4	23 04	Output HD, N,E
111	R↑	16-31	HD
112	RCL1	36 01	

REGISTERS

0	1	2	3	4	5	6	7	8	9
AZ	HD	LAT	DEP	AREA	Curve Area	ΣHD	BEG N	BEG E	180
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
AZ,R	Δ	πΔ/180			Point No.

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	RTN	24	
114	*LBLE	21 15	HD
115	RCL0	36 00	AZ for traverse
116	X⇄Y	-41	
117	F1?	16 23 01	
118	GTO4	22 04	Is traverse on?
119	RCLA	36 11	AZ for sideshot
120	X⇄Y	-41	HD
121	*LBL4	21 04	
122	F1?	16 23 01	Is traverse on?
123	ST+6	35-55 06	
124	STO1	35 01	
125	PRTX	-14	
126	→R	44	LAT
127	F1?	16 23 01	Is traverse on?
128	GTO2	22 02	
129	X⇄Y	-41	DEP
130	RCL3	36 03	DEP
131	+	-55	
132	RCL8	36 08	BEG E
133	+	-55	E=BEG E + DEP
134	X⇄Y	-41	LAT
135	RCL2	36 02	LAT
136	+	-55	
137	RCL7	36 07	BEG N
138	+	-55	N=BEG N + LAT
139	RCLA	36 11	AZ
140	GTO3	22 03	
141	*LBL2	21 02	
142	ST+2	35-55 02	LAT
143	X⇄Y	-41	
144	ST+3	35-55 03	DEP
145	2	02	
146	÷	-24	
147	RCL3	36 03	
148	-	-45	DEP - DEP/2
149	×	-35	
150	ST+4	35-55 04	LAT(DEP-DEP/2)
151	RCL3	36 03	
152	RCL8	36 08	
153	+	-55	E
154	RCL2	36 02	
155	RCL7	36 07	
156	+	-55	N
157	RCL0	36 00	AZ
158	*LBL3	21 03	Output point, N,E
159	→HMS	16 35	
160	ISZI	16 26 46	Increment point no.
161	RCLI	36 46	
162	SPC	16-11	
163	SPC	16-11	
164	PRTX	-14	Point no.
165	R↓	-31	
166	R↓	-31	
167	PRTX	-14	N
168	X⇄Y	-41	
169	PRTX	-14	E
170	RTN	24	
171	*LBLe	21 16 15	CURVE
172	CF2	16 22 02	Clear curve sign
173	STOA	35 11	Radius
174	X>0?	16-44	Radius positive?
175	SF2	16 21 02	
176	X⇄Y	-41	Δ
177	HMS→	16 36	
178	STOB	35 12	
179	SIN	41	Sin(Δ)
180	RCLB	36 12	Δ
181	D→R	16 45	
182	STOC	35 13	ΔPi/180
183	-	-45	Sin (Δ)-ΔPi/180
184	F2?	16 23 02	Radius positive?
185	CHS	-22	
186	RCLA	36 11	
187	X^2	53	R^2
188	×	-35	
189	2	02	
190	÷	-24	
191	ST+5	35-55 05	Segment area ⌓
192	SPC	16-11	
193	PRTX	-14	
194	RCL1	36 01	HD or chord
195	ST-6	35-45 06	
196	RCLC	36 13	
197	RCLA	36 11	
198	×	-35	Arc length
199	ABS	16 31	
200	ST+6	35-55 06	
201	RCLB	36 12	Δ
202	→HMS	16 35	
203	RCLA	36 11	Radius
204	PRST	16-14	
205	R/S	51	
206	*LBLa	21 16 11	FA/BRG
207	1	01	
208	F0?	16 23 00	Bearing on?
209	0	00	
210	SF0	16 21 00	Bearing on
211	X=0?	16-43	
212	CF0	16 22 00	Field angle on
213	R/S	51	
214	*LBLb	21 16 12	SS/TRA
215	1	01	
216	F1?	16 23 01	Traverse on?
217	0	00	
218	SF1	16 21 01	Traverse on
219	X=0?	16-43	
220	CF1	16 22 01	Sideshot on
221	R/S	51	

LABELS

A BEG N↑E	B AR,AL,BRG	C DR,DL,AZ	D SD↑ANG	E HD→N,E
a FA/BRG?	b SS/TRA?	c INV	d CLOSE	e Δ↑R
0 QDBRG→AZ	1 AZ	2 USED	3 OUT N,E	4 USED
5	6	7 USED	8 USED	9

FLAGS

0	FA/BRG
1	SS/TRA
2	CURVE SIGN
3	

SET STATUS

FLAGS	ON	OFF
0	☒	☐
1	☒	☐
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	4

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