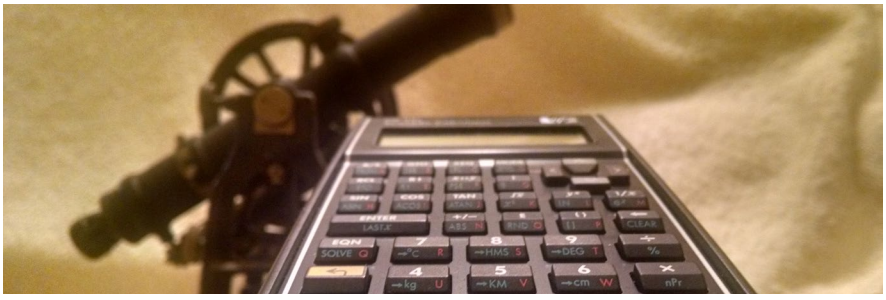
JASON E. FOOSE, PS

the HP 35s calculator

A Field Surveyor's Companion

Part 7—Area



According to Brown, Robillard, and Wilson's "Boundary Control and Legal Principles" third edition, area is the second least controlling factor in the order of conflicting title elements and followed only by coordinates. However in the public's eye area is a most important factor in identifying land. I believe that the simple description "Jason's 10 acres in Mohave County, Arizona," could serve to effectively and legally convey land. I'd be willing to bet that the PLSS guys are already thinking "660' x 660' ", the Colonial Boys are on their way to the courthouse to get my neighbor's deeds, and the Texans don't count anything under 40. Land ownership seems to be commonly associated with quantity. I suppose that's because quantity is an easy metric to scale with currency. The irony of that concept is that folks will fight over pennies, and real estate escrow accounts must balance at exactly $0.00, but the surveyor has been graced with the expectation of expressing quantities "more or less". Count your blessings and recognize the imprecision of your measurements when expressing significant digits.

Please do not hesitate to send any comments, concerns, questions, or criticism to *rls43185@gmail.com*.

This Month's Program

Program K: The Area program simply resolves the "area by coordinates" of a flat sided polygon then adds or subtracts the area of a segment of a circle for curve areas. Segments are added or subtracted accordingly dependent on if the curve is an "outie" or an "inny" to the polygon. Curve segment area formulae can be easily wrangled up on the fruited prairie of information we call "the internet". "Area by coordinates" can be referenced in many land surveying texts including "*Elementary Surveying*" Eleventh edition by Wolf and Ghilani. I find my oldest reference in "*Surveying*" by Davis, Foote, and Rayner copyright 1928. A boundary retracement surveyor is well served by pole-catting through the used book stores. Historic Engineering and Surveying textbooks demonstrate the techniques used by our predecessors. It stands to reason that knowing how your predecessor measured is requisite to successful retracement surveying.

*A 1.4 square foot difference (308,263.21) should show between last month's computed coordinates and the two place decimal values presented herein.

Example Data and Running The Program

PNT	NORTHING	EASTING
1	4,680.20	4,917.12
2	4,669.13	5,517.15
3	5,267.15	5,517.46
4	5,267.06	5,186.98
5	5,000.00	5,000.00
6	5,267.03	5,069.20
7	5,153.02	5,039.66
CRV	Δ 75°27'19"	RAD 152.2316*

*Follow consistent rules when computing to a level of precision. "Four decimal places" is well beyond my reasonable ability to measure as well as beyond the quality of any computed value in this example. Using the radius value carried out to 152.2316 yields a square footage of 308,261.82 whereas the value of 152.23 yields the value of 308,261.73 which equates to .09 of a square foot or the area of a classroom ruler. I honestly don't measure land that well, nor do you! However, you may want to expend some attention when large highway curves are encountered. Understanding the effects of computations is important in a mechanical sense but ultimately the varying computations should collectively net consistent and tolerable results. Society is not interested in the claim that your answer is "more righter" than mine. They simply expect us to agree...and another thing, please kindly round up those decimally inordinate "nines" for the Planning and Zoning folks. You have professional the discretion to round and interpret, whereas they most likely don't.

Use the data from the previous "Compass Rule Adjustment" routine. In addition to the five existing points I have introduced a curve with P.I. #6 and the P.T. #7 to show the complete function of the routine. I will demonstrate how to construct the curve and solve for the p.i. and p.t. in at a later date.

KEYSTROKE STEPS	RESULTANT DISPLAY	ACTION
XEQ √X ENTER	Y-reg : X-reg : AREA	Executes program {K} and displays program annunciator.
R/S	Y-reg: X-reg: CNTR CLKWSE	Annunciator/reminder to enter coordinate points going counterclockwise around the polygon.
R/S	Y-reg: X-reg: END W 1ST PNT	Annunciator/reminder that you must close the polygon by ending on the first point. Unlike "COMPASS RULE" points can be selected regardless of order and are not dependent upon any sequential order.
R/S	Y-reg : X-reg : RCL POINT	Annunciator.
R/S	Y-reg : J? X-reg : default value	Prompt for first point number.
1 R/S	Y-reg: (1)= X-reg: 4,680.20 *i* 4,917.12	Display point info for review.
R/S	"RUNNING" then Y-reg : X-reg : RCL POINT	Annunciator.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.
2 R/S	Y-reg : (2)= X-reg : 4,669.13 *i* 5,517.15	Display point info for review.
R/S	"RUNNING" then Y-reg : X-reg : RCL POINT	Annunciator.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.
3 R/S	Y-reg : (3)= X-reg : 5,267.15 *i* 5,517.46	Display point info for review.
R/S	"RUNNING" then Y-reg : X-reg : RCL POINT	Annunciator.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.
4 R/S	Y-reg : (4)= X-reg : 5,267.06 *i* 5,186.98	Display point info for review.
R/S	"RUNNING" then Y-reg : X-reg : 1=END 0=ADD	After the minimum 4 points are entered the program prompts for additional point entry.
0 R/S	Y-reg : X-reg : RCL POINT	Annunciator.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.
7 R/S	Y-reg : (7)= X-reg : 5,153.02 *i* 5,039.66	Display point info for review.
R/S	"RUNNING" then Y-reg : X-reg : 1=END 0=ADD	Prompt for additional point entry.
0 R/S	Y-reg : X-reg : RCL POINT	Annunciator.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.
1 R/S	Y-reg : (1)= X-reg : 4,680.20 *i* 4,917.12	Display point info for review.
R/S	"RUNNING" then Y-reg : X-reg : 1=END 0=ADD	Prompt for additional point entry. Point 1 is our closing point and P.O.B. of the polygon
1 R/S	Y-reg : X-reg : CURVE INPUT	Annunciator to begin curve data entry. Each curve is entered separately in a typical loop sequence.
R/S	Y-reg : X-reg : 1=YES 0=NO	Prompt to skip curve entry.
1 R/S	Y-reg : X-reg : DELTA RADIUS	Annunciator/reminder for delta and radius input values.
R/S	Y-reg : D? X-reg : default value	Prompt for delta in decimal degrees.(75.4553 DD)
75.2719 YLS 8 R/S	Y-reg : R? X-reg : default value	Prompt for radius.
152.2316 R/S	Y-reg : X-reg : ADD=1 SBTRCT=0	Prompt to add the segment area ("outie") or subtract segment area ("inny").
1 R/S	Y-reg : X-reg :0=MORE 1=END	Prompt to continue loop (add curves) or end.
1 R/S	Y-reg : X-reg : Y REG=SQ FT	Annunciator/reminder that Square Feet value will be displayed in Y-reg.
R/S	Y-reg : X-reg : X REG=ACRES	Annunciator/reminder that Acreage value will be displayed in X-reg.
R/S	Y-reg : 308,261.82 X-reg : 7.08	308,262 square feet and 7.08 acres.
R/S	Y-reg: X-reg: AREA	Return to top of program.

Program Listing

K001	LBL K
K002	SF 10
K003	EQN "AREA"
K004	EQN "CNTR CLKWSE"
K005	EQN "END W 1ST PNT"
K006	XEQ J001
K007	STO A
K008	x<>y
K009	STO B
K010	XEQ J001
K011	EQN B*REGX▶B
K012	EQN A*REGZ▶A
K013	RCL(J)
K014	XEQ J012
K015	STO D
K016	x<>y
K017	STO C
K018	XEQ J001
K019	EQN C*REGX▶C
K020	EQN D*REGZ▶D
K021	CF 10
K022	EQN A+D▶H
K023	EQN B+C▶I
K024	RCL(J)
K025	XEQ J012
K026	STO D
K027	x<>y
K028	STO C
K029	XEQ J001
K030	EQN C*REGX▶C
K031	EQN D*REGZ▶D
K032	EQN H+D▶H
K033	EQN I+C▶I
K034	EQN (H-I)/2▶K
K035	SF 10
K036	EQN "1=END 0=ADD"
K037	x=0?
K038	GTO K024
K039	CF 10
K040	EQN 0▶X
K041	EQN 0▶W
K042	EQN 0▶V
K043	SF 10
K044	EQN "CURVE INPUT"
K045	EQN "1=YES 0=NO"
K046	x=0?
K047	GTO K077
K048	EQN "DELTA RADIUS"
K049	CF 10
K050	EQN 0▶X
K051	EQN 0▶W
K052	EQN 0▶V
K053	CF 10
K054	FIX 4
K055	INPUT D
K056	EQN D/2▶C
K057	FIX 2
K058	INPUT R
K059	CF 10
K060	EQN (D/360)*SQ(R)*π▶Z
K061	EQN (R*SIN(C))*(R*COS(C))▶Y
K062	SF 10
K063	EQN "ADD=1 SBTRCT=0"
K064	x=0?
K065	GTO K070
K066	CF 10
K067	EQN Z-Y
K068	STO+ W
K069	GTO K073
K070	CF 10
K071	EQN Z-Y
K072	STO+ V
K073	SF 10
K074	EQN "0=MORE 1=END"
K075	x=0?
K076	GTO K053
K077	EQN "Y REG=SQ FT"
K078	EQN "X REG=ACRES"
K079	CF 10
K080	EQN ABS(K+W-V)
K081	EQN ABS(K+W-V)/43560
K082	STOP
K083	GTO K001
K084	RTN

Jason Foose is the County Surveyor of Mohave County Arizona. He has been licensed for ≈ 441,504,000 seconds...no wait, 441,504,001 seconds...no wait, 441,504,002 seconds...

Bonus Equations

HMS+ HMS-

Open the EQN library EQN;

Below 3X3 (linear solver) enter the following equations;

Addition HMS+

BRS 8 YLS 8 R↓ ENTER GREY RIGHT ARROW-(advances 1 space right) + YLS 8 R↓ GREY LEFT ARROW –(selects the X-reg) ENTER ENTER

Subtraction HMS-

BRS 8 YLS 8 R↓ ENTER GREY RIGHT ARROW (advances 1 space right) - YLS 8 R↓ GREY LEFT ARROW (selects the X-reg) ENTER ENTER

Screen Shot

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3*3 LIN. SOLVE
→HMS(HMS→(REGY)+HMS→(REGX))
→HMS(HMS→(REGY)–HMS→(REGX))
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Notes: BRS and YLS are right and left with colors; the grey arrows left and right are the arrow keypad in the upper right portion of the keyboard. They indicate moving the cursor. The "Roll down" key pulls up the addressing for the x & y registers.

To run:

Set display to fix 4;
HMS+ exit from EQN mode;
Enter an azimuth in HMS; 45.3030
Enter another azimuth in HMS; 90.3050
Hit the EQN
Select the HMS+ equation
Hit ENTER to run.
The solution 136.0120 will be in the X-reg in HMS.
Follow the same steps and select the subtraction equation if desired.