JASON E. FOOSE, PS

Linear Equations and a Land Development Scenario

Linear equations are powerful solving tools especially when unleashed from classroom confines of counting the number of legs on chickens and cows. We can utilize systems of linear equations for many applications like solving intersections, estimating project supplies, and in this case land development potential. The numbers used herein are merely presumptuous attempts at reasonable values. The objective of this exercise is to estimate how many lots a client could expect to net from a given parcel of land.

Client Request

The client inherited 10 acres of relatively flat and easy vacant ground. She would like to know how many lots she can offer in order to do a cost analysis for development and improvements.

Constraints

Local Zoning Code permits 6,000 square foot lots with 60' minimum frontage. Local Zoning Code permits 1.5 acre residential/agricultural. Local roadways are required to be a minimum 40' right-of-way.

Initial Concept

Our objective is to present the client with an initial concept and open the floor for discussion, feasibility, and alternatives. Our professional experience hints that a blend of high density and low density lots intermingled at a 2:1 ratio provides a solid opportunity for the incidental land developer in our post-apocalyptic housing market.

Forming Equations

We propose a division of 10 acres with twice as many 6,000 square foot lots as "one and a half" acre lots. Begin by aligning the units into acres (6000 sf=0.1377 acres) then phrase an equation that relates both lot sizes to the overall area. It sounds like this: *"The sum of a certain number of 1.5 acre lots and .1377 acre lots plus a certain amount of roadway is equal to 10 acres."*

$$1.5x + .1377y + z = 10$$

We have assigned "x" to be the number of big lots, "y" to be the number of small lots, and "z" to be the amount of roadway. Next let's establish the relationship between small lots and big lots. We want twice as many small lots as big lots "*so two times "x" number of lots should equal "y" number of lots.*"

$$2x = y$$

Re-arrange by subtracting "y" from both sides

$$2x - y = 0$$

The relationship between roadways and lots can be expressed by assuming that a length equal to the frontage of each lot will be reserved for half of the prescribed road's width. Local zoning guides us to consider all 6,000 square foot lots as being 60' wide and 100' deep. Having no other reason, we will assume that 1.5 acre lots are 255.62 feet square. So we need to form an equation that expresses half of the road width times each frontage then apply it to every lot accordingly. It sounds like this (read it aloud):

"Twenty feet times two-hundred fifty-five point sixty two feet, times one point five acres, times "x" number of lots, plus 20 feet times 60 feet, times .1377 acres, times "y" number of lots equals "z"." It looks like this:

$$(20 \times 255.62)1.5x + (20 \times 60).1377y = z$$

Re-arrange by subtracting "z" from both sides

$$(20 \times 255.62)1.5x + (20 \times 60).1377y - z = 0$$

We now have enough to form a system of linear equations. It is imperative that we organize our x, y, and z variables all on the same side of the equation and it simply flows well with the HP solver to collect them on the left side alphabetically.

Forming The System

$$1.5x + .1377y + z = 10$$
$$2x - y = 0$$
$$(20 \times 255.62)1.5x + (20 \times 60).1377y - z = 0$$

There is no 'z' in the second equation. However we need to accommodate 'z' to square up the system. This is accomplished by giving 'z' a value of zero in the second equation. We also must represent solo variables with 1 or -1 depending upon the leading operator of "+" or "-". The functioning system looks like this:

$$1.5x + .1377y + 1z = 10$$
$$2x - 1y + 0z = 0$$
$$(20 \times 255.62)1.5x + (20 \times 60).1377y - 1z = 0$$

THE HP 35s 3x3 SOLVER

The solver uses the linear form of Ax+By+Cz=D. The complete system looks like this:

$$Ax+By+Cz=D$$
$$Ex+Fy+Gz=H$$
$$Ix+Jy+Kz=L$$

The letters A thru L are the coefficients and x,y, and z are the solution variables. The 3x3 routine will request input for the coefficient registers A thru L. Our particular coefficients are as follows:

A: 1.5
B: 0.1377
C: 1

D: 10
E: 2
F: -1
G: 0
H: 0
I: 20 x 255.62 ÷ 43,560 x 1.5 (or 0.1760)
J: 20 x 60 ÷ 43,560 x .1377 (or 0.0038)
K: -1
L: 0

The stack is active within the 3x3 solver. Utilize the operators to combine (multiply/divide) the numbers for variables "I" and "J" then hit [R/S] to store the result and continue. Negative numbers are entered in typical HP fashion with [+/-].

Run the solver as shown on page 7-6 of the HP 35s User's Guide. Chapters 6 and 7 both explain the use of equations. I get the following results:

X = 5 large lots (1-1/2 acre)
Y = 10 small lots (6,000 square foot)
Z = Almost an acre in roadway (.9374)

These are cursory estimates rounded to practical units. They reasonably add up like this:

Five 1-1/2 acre lots are 7.5 acres;
Ten small lots or 60,000 square feet equals 1.4 acres;
An acre of 40 foot road is about 1,100 feet long on both sides for a total of 2,200 feet; Ten 60′ lot frontages plus five 250′ lot frontages equals about 1850 feet.
Hmmmm, ballpark.

The solutions seem reasonable in this light. Although this is an appropriate occasion to loosely apply measure, great consideration should be taken toward the client's understanding of your estimates. Your lot design proposal impacts the financial yield of the client's property and thus should be considered as a tenant of liability.

Feel free to email me at *rls43185@gmail.com* with any questions. ■

Jason Foose is the County Surveyor of Mohave County Arizona. He originally hails from The Connecticut Western Reserve Township 3, Range XIV West of Ellicott's Line Surveyed in 1785 but now resides in Township 21 North, Range 17 West of the Gila & Salt River Base Line and Meridian.

!OYE COMO VA!

I find that verbalizing a problem then restating it aloud helps me to "hear how it goes". The rules of arithmetic and algebra are rigid whereas the art of problem solving is the application of those rules in a world made of silly putty. Solving a problem requires the ability to describe the problem, identify the variables, and then check solution!

©2015 JASON E. FOOSE