# An Introduction to Larger Jump Set Models

As with smaller jump set models, it helps to start with the VF and with $n$ = 12 so we can talk in terms of hours for vertices. All jump sets with more than 3 jumps and $S$ > 1 must use the web model.

**The *Excel* equation model.** Here we use an *Excel* file that allows exploration of up to 9 jumps in the jump set via equations using the following additional parameters, $k$ is the number of jumps in the set, $d$ is the decline per jump, and $c$ is the initial offset from vertical. These parameters lead to the following jumps:

$J_1$ = INTEGER($n$/2)-$c$ and $J_i = J_1 - (i\text{-}1)\cdot d$, for $i$ = 2, …, $k$.

These equations allow orderly examination of jump sets without having to manually change values.

**Organization of these images.** This explainer sets $d$ = 1 and $c$ = 0. These three image have $n$ = 12 and the next page has $n$ = 13. On both pages $k$ increases from $k$ = 4, 5, and 6 at top, middle, and bottom. Note that INTEGER(12/2) = INTEGER (13/2) = 12 so jumps are the same on both pages (but of course they are easier to conceptualize on this page since vertices are hours of a clockface). Given $d$ = 1, jumps decline 1 starting at 6 = $n$/2 ($c$ = 0).

The 4 jump model is (6,5,4,3) which sums to 18.

The 5 jump model is (6,5,4,3,2) which sums to 20.

The 6 jump model is (6,5,4,3,2,1) which sums to 21.

The [VCF and *vertices used* rules laid out earlier] still apply,

VCF = GCD($J_1$+$J_2$+…+$J_k$,$n$).

Vertices used (and lines in VF) = $k\cdot n$/VCF.

Applying this information to the three VF images on this page we confirm how the images were created on this page.

**Top Image.** VCF = GCD(18,12) = 6 so Vertices used = 48/6 = 8.

The order of lines in image creation is:

0-6-11-3-6 – 0-5-9-0,

where there is a longer dash between jump sets.

This 8-line image was created in two 4-line jump sets.

**Middle Image.** VCF = GCD(20,12) = 4, Vertices used = 60/4 = 15.

The order of lines in image creation is:

0-6-11-3-6-8 – 2-7-11-2-4 – 10-3-7-10-0.

This 15-line image was created in three 5-line jump sets.

**Bottom Image.** VCF = GCD(21,12) = 3, Vertices used = 72/3 = 24.

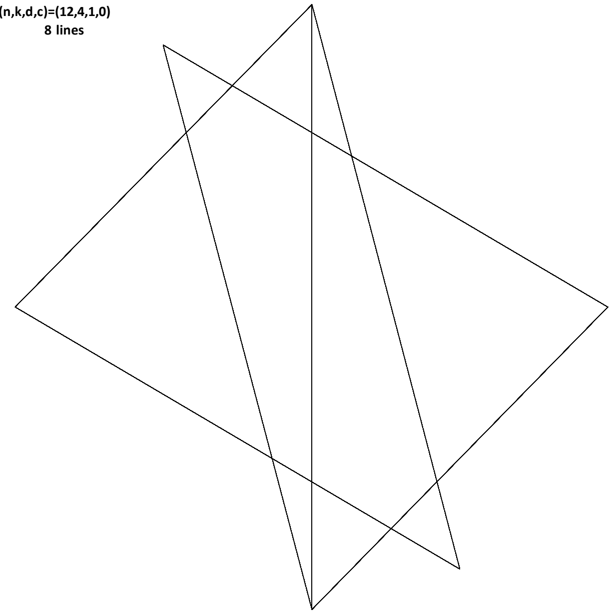
The order of lines in image creation is:

0-6-11-3-6-8-9 – 3-8-0-3-5-6 – 0-5-9-0-2-3 – 9-2-6-9-11-0.

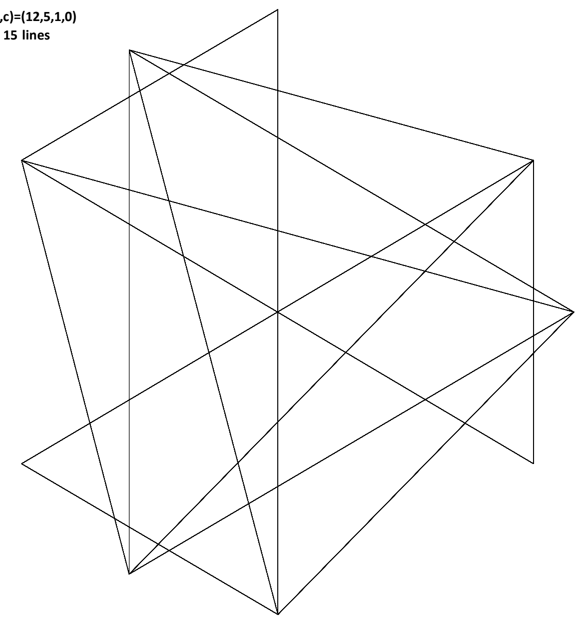
This 24-line image was created in four 6-line jump sets.

Each of these images has less than $k\cdot n$ lines because VCF > 1. Such issues are less likely the case if $n$ is prime.

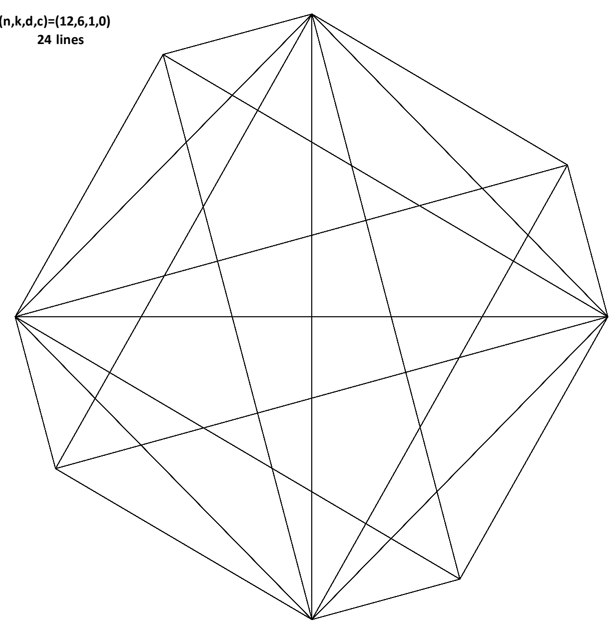
(n,k,d,c)=(12,4,1,0)
8 lines



(n,k,d,c)=(12,5,1,0)
15 lines



(n,k,d,c)=(12,6,1,0)
24 lines



**Prime *n*.** The only difference here is that these are ***n*** = 13 images. Each image has VCF = 1 as will be the case when ***n*** is prime (unless the sum of jumps in a set is a multiple of ***n***). Therefore, each image has ***k·n*** lines.

**An *Excel* assist.** When ***n*** ≠ 12 we cannot use hours, but we can easily determine the drawing order using *Excel* in 4 equations (see table notes). This table was created for the top image, but one could readily do 5 or 6 by adjusting the jump set pattern before repeating that pattern (as was done in B6 for ***k*** = 4).

**Stacked Stars.** When VCF = 1, there will be 2***k*** lines at each vertex of the VF. For example, the 8 lines associated with vertex 0 are on either side of the **four green highlighted** cells below.

The lines at each vertex are paired with one another and create stacked stars. For example, there are 4 stars in the top image, one associated with each of the four jump levels 6, 5, 4, and 3. You can add or remove these stars using the ⬍ ***k*** arrows in the *Excel* file. *Note that the middle adds a 13,2-star to the top and the bottom adds a 13,1-star (i.e., a 13-gon) to the middle.*

**Mystic Rose.** The bottom image is sometimes called a *Mystic Rose*. Such images have the property that *every vertex is connected to every other vertex* in the image. Given ***n*** = 13, there are 12 lines emanating from each vertex or 78 = 13·12/2 lines total (13 vertices, 12 lines per vertex, but each line has 2 ends, so you must divide by 2 to avoid double counting), just as noted on the image.

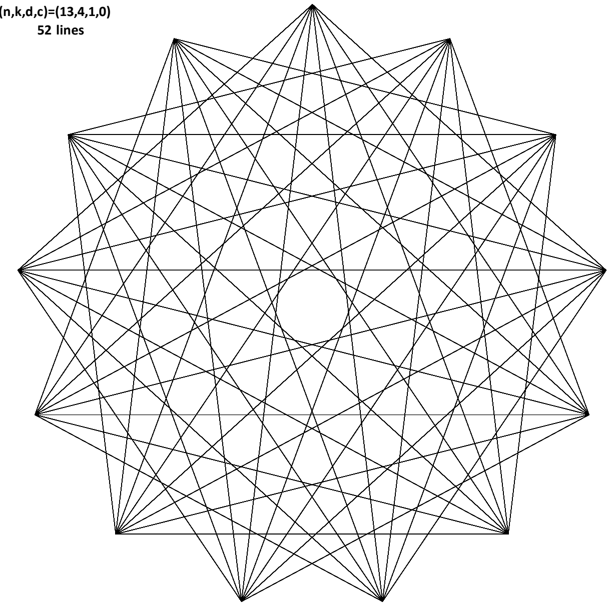
| Line | Jump | Sum | Vertex | Line | Jump | Sum | Vertex | Line | Jump | Sum | Vertex |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 6 | 6 | 19 | 4 | 87 | 9 | 37 | 6 | 168 | 12 |
| 2 | 5 | 11 | 11 | 20 | 3 | 90 | 12 | 38 | 5 | 173 | 4 |
| 3 | 4 | 15 | 2 | 21 | 6 | 96 | 5 | 39 | 4 | 177 | 8 |
| 4 | 3 | 18 | 5 | 22 | 5 | 101 | 10 | 40 | 3 | 180 | 11 |
| 5 | 6 | 24 | 11 | 23 | 4 | 105 | 1 | 41 | 6 | 186 | 4 |
| 6 | 5 | 29 | 3 | 24 | 3 | 108 | 4 | 42 | 5 | 191 | 9 |
| 7 | 4 | 33 | 7 | 25 | 6 | 114 | 10 | 43 | 4 | 195 | **0** |
| 8 | 3 | 36 | 10 | 26 | 5 | 119 | 2 | 44 | 3 | 198 | 3 |
| 9 | 6 | 42 | 3 | 27 | 4 | 123 | 6 | 45 | 6 | 204 | 9 |
| 10 | 5 | 47 | 8 | 28 | 3 | 126 | 9 | 46 | 5 | 209 | 1 |
| 11 | 4 | 51 | 12 | 29 | 6 | 132 | 2 | 47 | 4 | 213 | 5 |
| 12 | 3 | 54 | 2 | 30 | 5 | 137 | 7 | 48 | 3 | 216 | 8 |
| 13 | 6 | 60 | 8 | 31 | 4 | 141 | 11 | 49 | 6 | 222 | 1 |
| 14 | 5 | 65 | **0** | 32 | 3 | 144 | 1 | 50 | 5 | 227 | 6 |
| 15 | 4 | 69 | 4 | 33 | 6 | 150 | 7 | 51 | 4 | 231 | 10 |
| 16 | 3 | 72 | 7 | 34 | 5 | 155 | 12 | 52 | 3 | 234 | **0** |
| 17 | 6 | 78 | **0** | 35 | 4 | 159 | 3 | | | | |
| 18 | 5 | 83 | 5 | 36 | 3 | 162 | 6 | | | | |

**Note.** The table is cut into thirds to conserve on space.

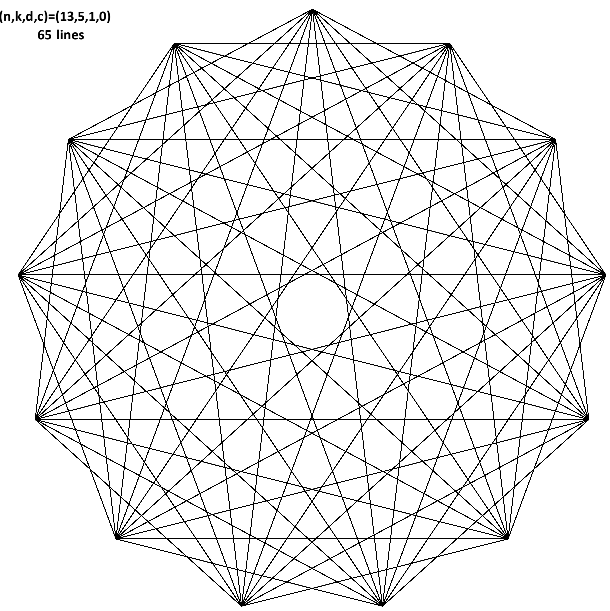
Enter jump pattern in cells B2 to B5, given a four jump set.

| Equations in cell: | | |
|---|---|---|
| C2 | =B2 | |
| D2 | =MOD(C2,13) | Drag down. |
| C3 | =C2+B3 | Drag down. |
| B6 | =B2 | Drag down. |

(n,k,d,c)=(13,4,1,0)
52 lines



(n,k,d,c)=(13,5,1,0)
65 lines



(n,k,d,c)=(13,6,1,0)
78 lines