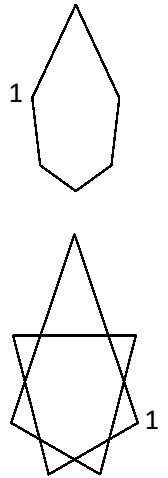# *One Level Change* Images

As you play around with the file you will inevitably come across images that are smaller than you would expect – they do not seem to use the bottom half of the vertex frame. For example, the top image to the right, (**S, P, J, n**)=(6, 19, 6, 19), and bottom image to the right (**S, P, J, n**)=(7, 19, 7, 19) both take up only about the top quarter of a normal image. The first segment endpoint is noted in each image.

1

Both images were created by setting **S** = **J** and **P** = **n** with the additional restriction that **S** < **n**/2. The resulting images have **S** segments. Once **S** > **n**/2, the images include the center of the circle. The first is a *One Level Change* image but the second is not.

Such images are very useful for showing off concentric interior circles of points. Given **S** = 6, and **S** = 7, three levels of points are expected and three can be seen, even without subdivisions showing on each image. In the top image: Points 1 and 5 are at Level 1; Points 2 and 4 are at Level 2; and Point 3 is at Level 3. In the bottom image: Points 1 and 6 are at Level 2; Points 2 and 5 are at Level 3; and Points 3 and 4 are at Level 1.

1

***One Level Change* Images.** These examples are useful for pointing out a specific kind of image, one that steps up or down by a single level each time a new point is added to the image. There are many forms that these images take but they have one thing in common: They move in and out one level at a time. Images that move in and out one level at a time must have the following relation between **P** and **S**:

> The ***One Level Change* Criterion**: **P** = **a*****S** ± 1 where **a** is a whole number.

In words, **P** must be 1 larger or one smaller than a multiple of **S**. The upper image satisfies this criterion (19 = 3*6 + 1) but the bottom image does not (19 = 2*7 + 5 and 5 is 2 subdivisions from a vertex end given **S** = 7 so Point 1 is Level 2).

Consider the location on the vertex frame of the first couple of points given **P** = **a*****S** ± 1.

Point 1 is within a single subdivision of a vertex frame endpoint (since all vertices are multiples of **S**). This is a point at Level 1 as discussed in the *Subdivisions Create Concentric Circles* note.

Point 2 is at subdivision 2**P** = 2*(**a*****S** ± 1) = 2***a*****S** ± 2, 2 points away from a vertex frame endpoint. This is at Level 2.

Subsequent points work in the same way. They move one level at a time, first in, then out. An annotated version of the upper right image is included on the next page showing the placement of Points 1, 2, and 3 on the vertex frame.

1
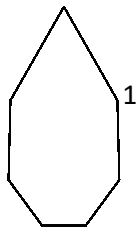
The only time when the level does not change is when the inner-most level is achieved, and **S** is odd. The image to the left changes **P** = **n** to 20 given **S** = **J** = 7. The criterion is once again satisfied, (20 = 3*7 – 1). The image is now drawn in a clockwise direction around the 7 segments (but if you change **P** = **n** to 22 the reverse will occur). Notice that the 3rd and 4th image points are both at Level 3 in this instance.

One Level Change images occur in a number of image types including the examples below: Even Porcupine images, Quivering Polygons, Stacked Circles and Chrysanthemums.

EP: https://www.playingwithpolygons.com?vertex=8&subdivisions=21&points=83&jumps=1

QP: https://www.playingwithpolygons.com?vertex=119&subdivisions=120&points=119&jumps=40

SC: https://www.playingwithpolygons.com?vertex=41&subdivisions=12&points=119&jumps=20

Ch: https://www.playingwithpolygons.com?vertex=41&subdivisions=12&points=23&jumps=20

The first two examples show that *One Level Change* images are harder to see when lines cross back and forth (from top to bottom or side to side) but they can be seen in the way that the image fills in. Consider how the bottom right and top left points are filled in in the EP image (from vertices 4 to 3 and 8&0 to 7). From vertices 4 to 3 the Level pattern is Level 1, 3, 5, 7, 9, 10, 8, 6, 4, 2, 0. (If you wonder why Level 10 is used rather than 11 it is that 10 = **S** – 11 = 21 – 11.) As this is happening, the Level pattern from 8&0 to 7 is Level 2, 4, 6, 8, 10, 9, 7, 5, 3, 1. Every other level is filled in both places. The rest are filled in in the second pass through. *One Level Change* images are easier to see when points are close to one another (as with the last two examples). It is worth noting that the last two examples only differ by **P**.
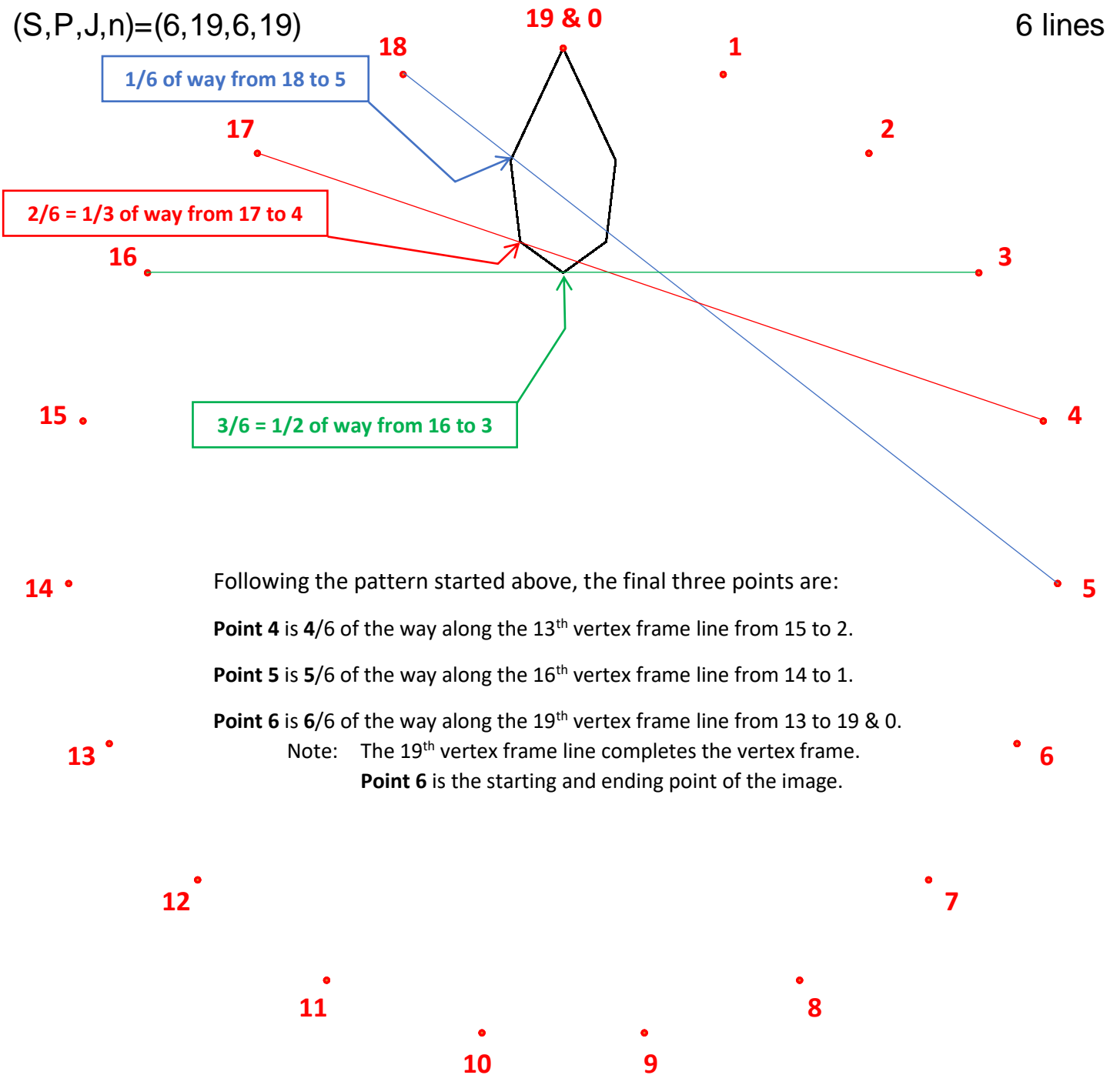
The image below shows the location of the first 3 points on their respective parts of the vertex frame. Each part has 6 subdivisions. Additional portions of the vertex frame are excluded to draw attention to how the image was formed.

Point 1 is the **first** subdivision on the 4th line of the vertex frame, 19 = 3*6 + 1. The first 3 jumps on the vertex frame are from 0 to 6 to 12 to 18. **The 4th line of the vertex frame is 18 to 5, in blue.**

Point 2 is the **second** subdivision on the 7th line in the vertex frame, 2*19 = 38 = 2*(3*6 + 1) = 6*6 + 2. The 5th and 6th jump on the vertex frame are from 5 to 11 to 17. **The 7th line on the vertex frame is from 17 to 4, in red.**

Point 3 is the **third** subdivision on the 10th line in the vertex frame, 3*19 = 57 = 3*(3*6 + 1) = 9*6 + 3. The 8th and 9th jump on the vertex frame are from 4 to 10 to 16. **The 10th line on the vertex frame is from 16 to 3, in green.**

(S,P,J,n)=(6,19,6,19)   **19 & 0**   6 lines

18

1/6 of way from 18 to 5

17

2/6 = 1/3 of way from 17 to 4

16

3/6 = 1/2 of way from 16 to 3

15

14

Following the pattern started above, the final three points are:

Point 4 is **4**/6 of the way along the 13th vertex frame line from 15 to 2.

Point 5 is **5**/6 of the way along the 16th vertex frame line from 14 to 1.

Point 6 is **6**/6 of the way along the 19th vertex frame line from 13 to 19 & 0.
                    Note: The 19th vertex frame line completes the vertex frame.
                    Point 6 is the starting and ending point of the image.

13

12

11

10   9