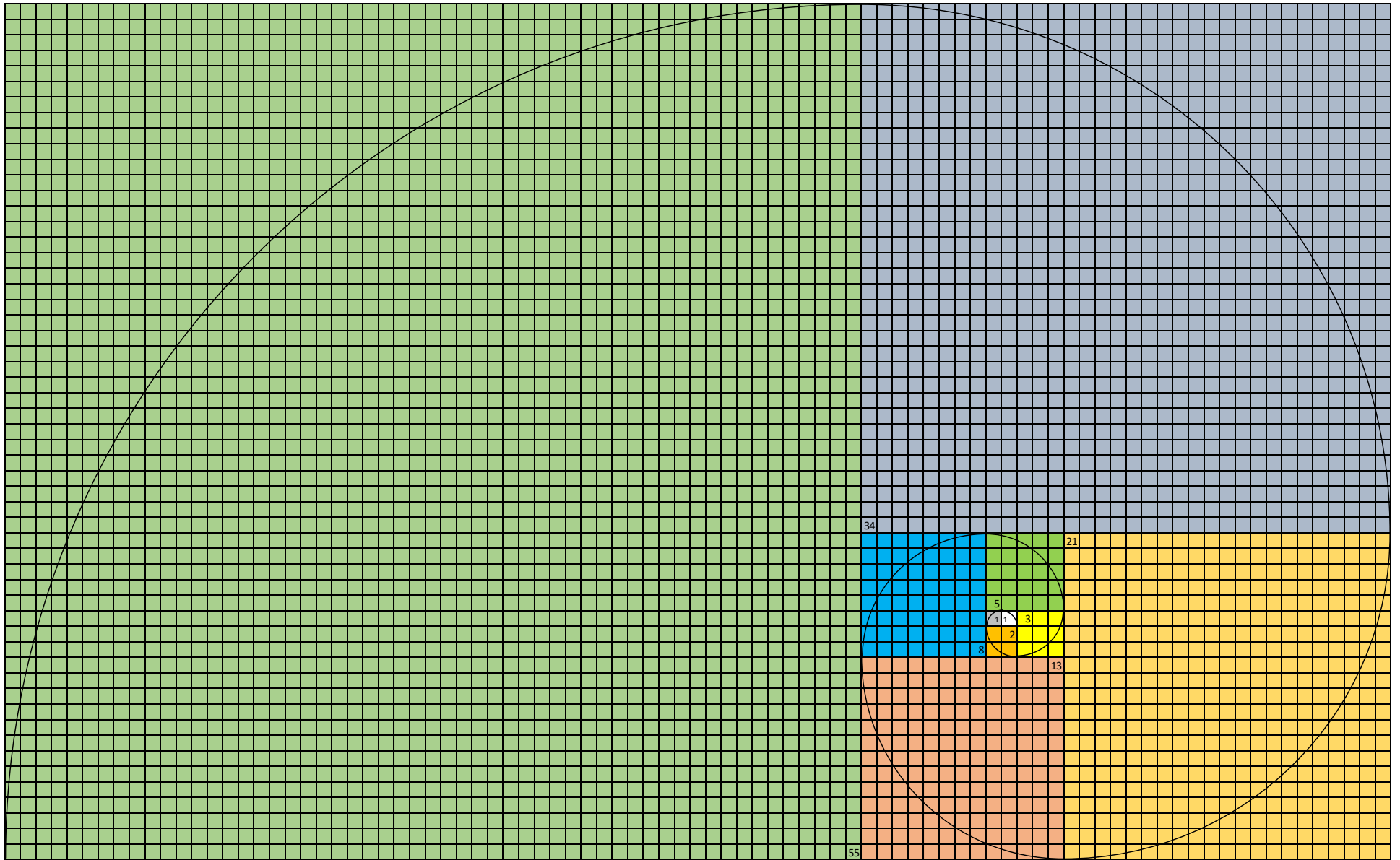


Fibonacci Golden Spiral Approximation in *Excel* (A Guided Challenge Question)

This approximation to the Golden Spiral using the first 10 Fibonacci numbers did not take very long to create in *Excel*. It may be a worthwhile exercise to do it yourself. You could also do this with graph paper (that is provided on p. 3) and compass. The instructions are on p. 2.



Although this has nothing to do with string art, the Fibonacci sequence was used as a point of reference in the discussion of larger jump sequences. It is surprisingly easy to create the image on the prior page from a blank *Excel* spreadsheet. Here is how.

Creating graph paper. When *Excel* opens, it typically has a row height of 20 pixels. You can check that by going to any of the numbers to left hand side of the sheet that designate row and move your mouse down until you see a horizontal line with arrows up and down. It should say Height 20 pixels. Put your mouse on the column label A press your mouse down and scroll right until you are at least 120 columns over (I stopped at column DP which is the 120th column). All columns up to DP should be highlighted. Then put your pointer between any column edge (and see a vertical line with arrows right and left). Reduce the size of columns from 64 to 20. This will give a gridwork. Finally, in the font area, click the area just above the Row 1 label and the left of the Column A label. This highlights the entire worksheet. Choose *All Borders* from the dropdown menu and it gives gridwork that will show up even with colored squares.

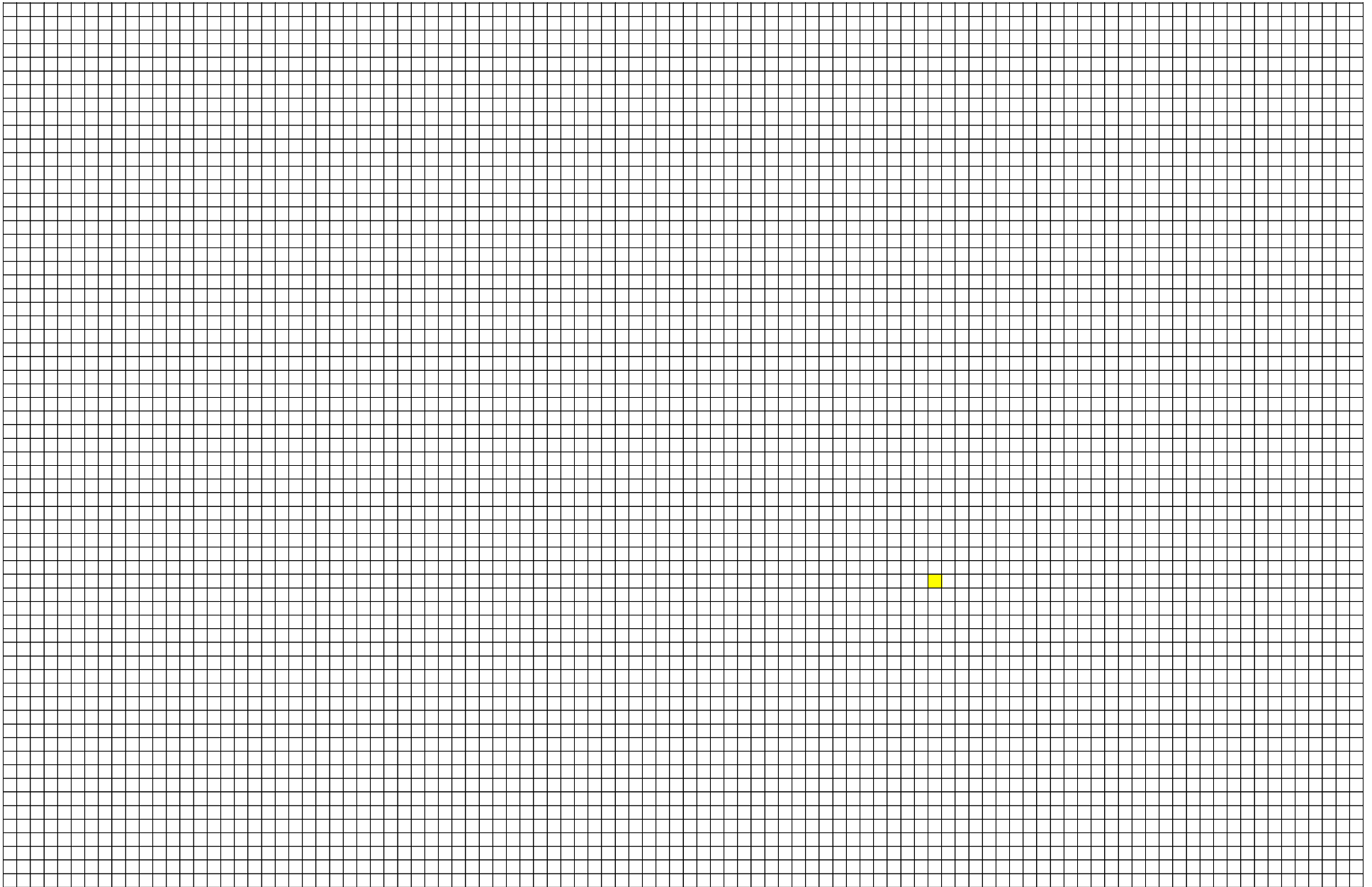
Creating the colored squares. I started in BN45 (the white square). I added a gray square to the left. Then the gold square below, and so on. The squares are easy because as you highlight a set of cells it tells you how many rows and columns you have highlighted. Note that each added square after the first two has a side whose length is the sum of the previous two squares. This is exactly how the Fibonacci numbers are created. Any value is the sum of the prior two.

Creating a quarter circle. Once you have the squares colored, it is time to add the quarter circles. They are easy to create in *Excel*. Click *Insert, Illustrations, Shapes*. Among the *Basic Shapes* is an option called *Arc*. If you open it up and play with it you will see that its default is to give you a curved image in the upper right 4th of the image. If the side lengths are the same, it is a quarter circle. Given this, I suggest the first quarter circle you create is either the one associated with 5 or 34. To get the size correct, simply place the upper right corner of the tool in the upper right corner of the square and move the left side and the bottom side down until you get left and bottom points of the quarter circle to the left upper or bottom right corner of the square. Note that to do this you have to have the size of the drawing tool TWICE as large as the radius you want. Color the line whatever color you want using *Shape Format* (I used black but light blue is the starting point and I also increased the *Weight* to 1 pt).

Turning and resizing the quarter circle. Once you have one quarter circle created, use it rather than start over with another *Arc*. Do this by Clicking on the image and click *Copy, Paste*. Click on the new image and then click *Shape Format, Rotate* and rotate in either direction then redo what you just did in terms of resizing. If you do this 9 times total (together with the first) you will have created the Golden Spiral.

Modifying the image (if you want). There are two things you might consider doing. First, you could remove the square gridwork so that the spiral will become more well defined. Second, you might consider changing the whole sheet to *White*, then the spiral will simply be on a white background, and no one will be able to figure out how you created it. You can do both tasks by using the area just above the Row 1 label and the left of the Column A label just as you did before to add the gridlines.

If doing this as a *Paper and Compass* exercise, you need at least a 60x100 piece of graph paper. The final image is 55x89. Start in the yellow highlighted cell.



1. Add squares following the first 10 Fibonacci numbers $F_1 - F_{10}$ (1, 1, 2, 3, 5, 8, 13, 21, 34, 55) as side lengths, to the side whose length is that number. The second 1-sized square is just to the left of the yellow square, the third is below, and so on. 2. As each square is added, draw a quarter circle with radius F_k connecting with the previous quarter circle. The center of a quarter circle is the corner of each added square (the final image has numbers in those corners).