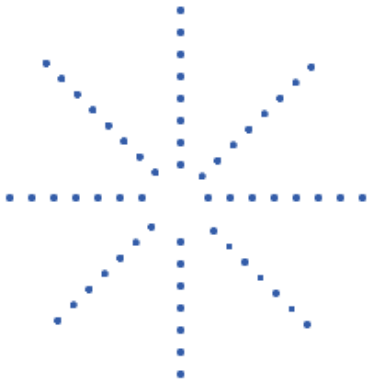
Spiral phyllotaxis is a characteristic arrangement of leaves, petals, scales or seeds that is seen in a variety of plants including daisies, sunflowers, pine cones and cauliflower. The cause of this beautiful natural pattern has only recently been explained fully. The explanation involves an interesting mix of mathematics, biology and physics. At the growth tip of a plant (called the **meristem**) small protusions called **primordia** emerge at regular intervals and move away radially from the center. Eventually these primordia go on to develop into various features of the plant such as its petals or seeds. In this workshop you will investigate how the primordia arrange themselves into a characteristic spiral pattern and why the number of spirals is so often a Fibonacci number.

1. One model of growth for the primordia is to assume that each primordium emerges from the meristem at a fixed angle relative to the previous primordium. The angle separating neighbouring primordia is called the **divergence angle**. In this activity we will try out various divergence angles to see which gives the most efficient packing. We will do this by plotting points (or preferably coloured dots) representing primordia on polar graph paper. Plot the first dot at $\theta = 0$ and $r = 10$. For each subsequent point increase θ by the chosen divergence angle and increase r by one unit. **Do not connect the dots.** The spiral that is formed by connecting the dots together in the order they are plotted (i.e. in the order that the primordia grow) is called the **generating spiral** However, we are not interested in the generating spiral, but rather in the spirals or lines that emerge as our eyes make connections between nearest neighbour dots. These spirals are called **parastichies**.

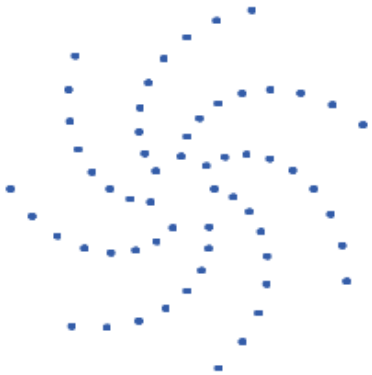
   (a) Each member of the group should choose a different one of the following divergence angles, 45^o, 90^o, 120^o, 135^o and 150^o. Plot enough points so that the parastichies become evident (you will need as many as 36 in some cases) and in pencil connect the dots along each parastichy.

   (b) Now each member of the group should repeat the exercise above but choose an angle that is 5^o larger than the one they chose at first.

   (c) Finally everyone should repeat the exercise using a divergence angle of 137.5^o (it may be helpful to measure out this angle once on a triangular wedge to use as a template). You will likely need 36 or more primordia to see the parastichies.

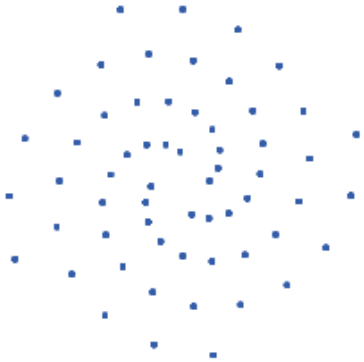


45°

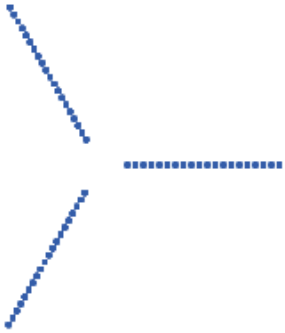


50°

90°

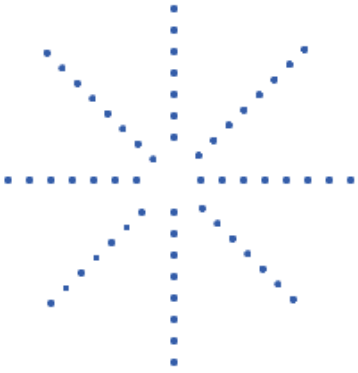


95°

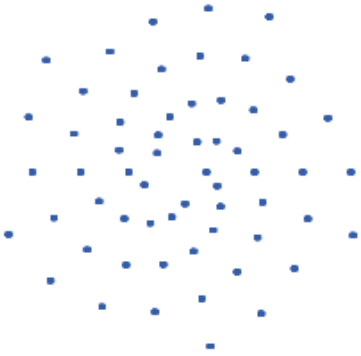


120°

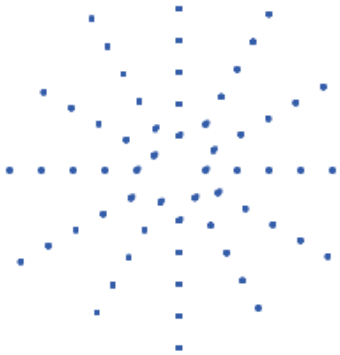
125°



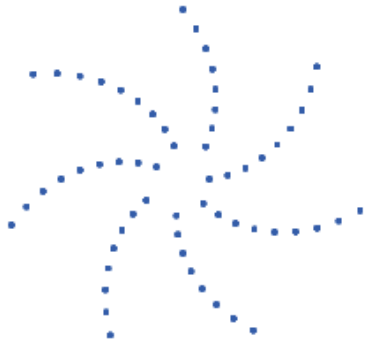
135°



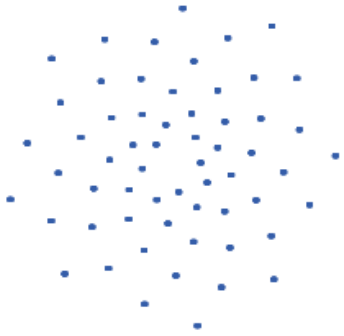
140°



150°



155°



137.5°

2. Draw a rough sketch of each pattern of parastichies created by the members of the group. Record the divergence angle for each diagram carefully, and make sure you accurately represent the number and shape of the parastichies as you will use these results in your homework assignment.