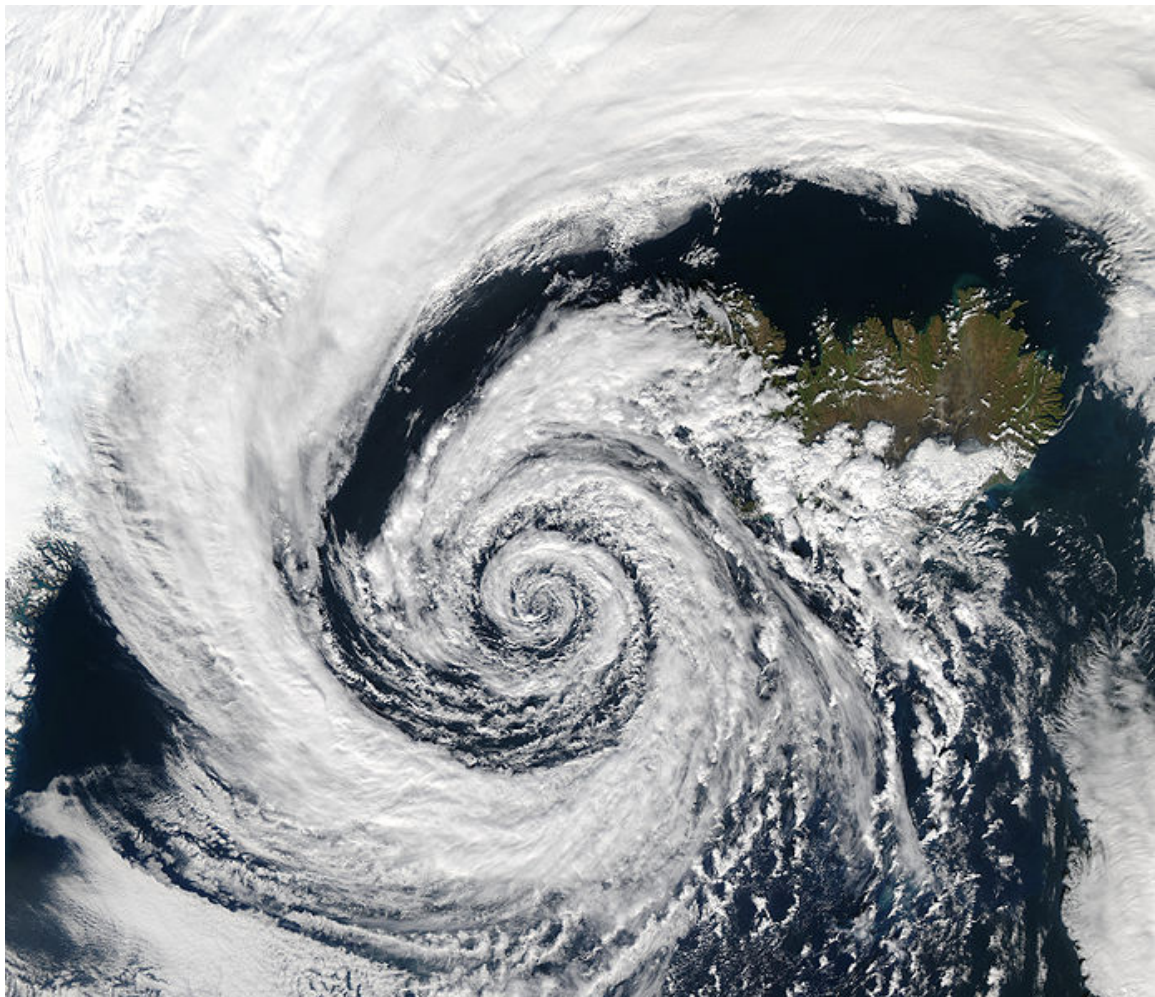


Answer the following questions on a separate sheet of paper and turn in your responses by 9:00 am on Wednesday February 9th.

1. A measuring tape with a thickness of 1.5 mm, is coiled around a rod with radius 2.0 cm. Find an expression for the radius of the roll of tape as a function of the number coils  $n$ . What type of spiral is this? What is the radius if there are 20 turns?
2. A snail shell grows in a spiral by accretion. If the radius of the shell increases by 10% (ie a factor of 1.1) every  $30^\circ$  Find an expression for its radius as a function of angle  $\theta$ , measured from a starting radius of 2 cm. What type of spiral is this? How large is the shell if it makes two complete turns beyond radius 2 cm?
3. For the following picture of a hurricane, draw a smooth curve roughly around the outer edge of the spiral cloud staring from the middle of the left hand side of the picture until you reach the center. Now measure the radius of the spiral every  $90^\circ$ . Find the ratio between neighboring terms? Is this a reasonably good logarithmic spiral? If so, find its equation.



4. Answer the following questions based on the parastichies patterns you generated with your group in this week's workshop.
  - (a) Which divergence angles result in parastichies that are straight lines? How many lines are there in each case. Explain, mathematically, why they line up in a straight line. Explain how the divergence angle relates to the number of straight lines that emerge.
  - (b) When the divergence angles are changed by  $5^\circ$  describe the changes in the parastichies pattern you observe. Is the shape of the parastichies the same? In which cases do the number of parastichies stay the same and in which cases do the number of parastichies change? Explain mathematically.
  - (c) In the case where the divergence angle is  $137.5^\circ$  you should be able to see two different ways to connect the dots to form parastichies. How many spirals do you get by each method of connecting the dots? Are these numbers familiar?
  - (d) Of all the patterns which results in the arrangement that is most uniformly packed?
5. For the divergences angle of  $137.5^\circ$  the number of spirals in each way of forming the parastichies should be neighbouring Fibonacci numbers. There is a mathematical reason for this
  - (a) For any given divergence angle  $\alpha$  there is a complementary angle  $360^\circ - \alpha$  which would generate an identical pattern. For example a divergence angle of  $270^\circ$  generates the same pattern as a divergence angle of  $90^\circ$ . Why?
  - (b) For the divergence of angle of  $137.5^\circ$  find the complementary angle. Find the ratio of the complementary angle to the divergence angle in this case. What is this number? What is its connection to Fibonacci numbers?
6. Create a drawing on a blank piece of paper of the pattern that emerges for the divergence angle  $137.5^\circ$ . Replace the dots in your diagram with some representation of a plant structure of your choice (eg seeds, scale, petals, or florets). Consider altering the size, shape and color of the structures as you move radially outward to make your pattern more natural. Be creative.