Name:_____
Partner:_____
Partner:_____

Physics 101 Lab 9: Leaves and Trash Bags

1 Purpose

To explore the ways in which a variety of mathematical concepts can help us understand the behavior of physical systems like tearing trash bags or the growth of leaves and flowers.

2 Tearing Plastic Bags

1. Each group will be given a piece of a plastic bag. Dr. T will cut a small slit in one edge of the sheet. This slit will be the starting point for tearing the sheet. Your first task is to tear the bag by pulling slowly and steadily outward on the edges of the sheet.

2. Once you have torn your plastic sheet, take a look at one of the torn edges. Draw a picture of the edge in the space below.

3. What you see looks a lot like something you have seen in the MAT 105 class. Can you remember what it is? Take a moment to think about it. Write your answer in the space below. If you can't think of it after a while, ask Dr. T.

4. Now take a look at the edge under a microscope. Dr. T will assist you with this part. Draw a picture of what you see in the space below.

5. Is torn edge a fractal? Explain why or why not.

6. Focus on a small portion of the torn edge. If you could make several copies of this portion, could those copies be combined to create a larger version of the same pattern? If so, how many copies would you need to make the pattern repeat on a larger scale?

7. By what factor is this larger pattern (formed of copies of the smaller pattern) bigger than the original smaller pattern? You don't need to measure this, just estimate it.

8. Estimate the fractal dimension of the torn edge. Remember that if you can use N copies of a fractal to construct an identical fractal that is S times as large, then the fractal dimension of the fractal is given by $d = \log(N)/\log(S)$.

9. Stop once you get to this point. Dr. T will give a short lecture before letting you continue with the lab.

3 Geometry on a Torn Trash Bag

1. Get a transparent plastic sheet from Dr. T and draw a grid of small dots on the sheet. Make sure you cover a significant portion of the sheet with this grid of dots. Then make a small cut in one edge of the sheet and tear the sheet as you did with the garbage bag.

2. Carefully observe what has happened to the distance between consecutive dots near the torn edge. Dots closer to the edge are _____ than dots that are far from the edge.

3. Why do you think the distance between dots near the edge of the sheet changes? Note that this is similar to what happens in curved spacetime.

4. Stop once you get to this point. Dr. T will give a short lecture before letting you continue with the lab.

4 Making Waves

1. You should have several small paper triangles on your table. You should also have some tape. Your first task in this part of the lab is to place three triangles together so that they share a common vertex. Lay the three triangles on the table and align them so that they share a common vertex and so that adjacent triangles share a side. Tape the adjacent triangles together along their shared side. There should be a gap between two of the triangles. Fold these two triangles so that they meet (but don't tape them together). This forms part of a geometric object that you have seen in the MAT 105 class. What is this object called?

2. Now lay the three triangles flat and add a fourth triangle into the gap. Repeat the procedure described above. Again, you get part of a geometric object that you have seen in the MAT 105 class. What is this object called?

3. Lay the four triangles flat, add a fifth triangle, and repeat the previous procedure. The shape you get is part of what geometric object?

4. Now lay the five triangles flat and add a sixth triangle. What happens?

5. Now add a seventh triangle. This is a bit tricky, so take your time. When you have figures out how to add the seventh triangle, tape any shared sides together if they have not already been taped. Continue to add to your creation by putting seven triangles together at each vertex and taping them together. Continue this until you have run out of triangles. The surface you create in this way is said to have "hyperbolic geometry." Would you say that the edge of the torn plastic you looked at earlier also has hyperbolic geometry? Explain why or why not.

6. When everyone is finished we will try to tape these hyperbolic surfaces together to form one large surface.

5 Homework

For homework you will read the article entitled "Leaves, Flowers, and Garbage Bags: Making Waves" by Sharon, Marder, and Swinney. After you have read the article, each person must answer the following questions on a separate sheet of paper.

1. Define spontaneous symmetry breaking in your own words.
2. What is a metric and for what is it useful?
3. Explain how the way certain leaves and flowers grow causes them to develop intricate, wavy shapes.
4. In your opinion, does knowing how flowers create their beautiful shapes make the flowers less beautiful? Or does it give you a greater appreciation of their beauty?

6 What You Must Turn In

When you come to lab on December 2 you must turn in:

1. This handout with all questions answered and all blanks filled in. Only one of these needs to be turned in per group.
2. Your completed homework assignment on a separate sheet of paper. Each person must turn in their own homework assignment.

Your grade will be determined by an equally weighted combination of your grades on the handout and on the homework assignment.