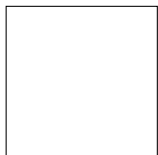


Extra Credit: A Tour of the Lowe Art Museum at the University of Miami

Instructions: In order for this assignment to be graded, you must attach your Lowe Museum visit sticker in the box below. Answer the questions in the handout completely; don't forget to use what we've learned about symmetry in class.



What kinds of words pop into your head when you think of art?

What kinds of words come to you when you think of math?

Definition. *Symmetry* is a characteristic of geometrical shapes, equations, and other objects; we say that such an object is *symmetric with respect to a given transformation* if this transformation, when applied to the object, results in something that looks exactly the same. We call such a transformation a *symmetry*.

The Artwork.

1) a) What kind of *symmetries* do you see in this big square painting by artist Frank Stella entitled *Le Neveu de Rameau*?

b) How many of each kind of *symmetries* can you count?

c) Recall from the beginning of our course that we can tessellate the plane with squares; suppose now the entire plane were tessellated with these Stella paintings. Does this infinite extension to the plane add more *symmetries*?

2) Now, take a look at Roy Lichtenstein's *Modular Painting in Four Panels*. Compare the symmetries of this painting with Stella's. They're both squares, so does that mean they have the same *symmetries*? If not, which has more? What if we tessellate the plane with this square painting—do we get more or fewer *symmetries* than with Stella's? Write a paragraph or two about this.

Just as numbers measure size (length, area, volume, etc.), mathematical things known as *groups* measure symmetry. ¹ We will learn more about *groups* in the next couple classes and you will need to know the definition of a group given in the footnote.

¹A *group* is a set G together with a multiplication $*$ on G which satisfies four axioms:

- 0) For all a, b in G , $a * b$ is also an element of G ;
- i) For all a, b, c in G , $(a * b) * c = a * (b * c)$;
- ii) There is an element e in G such that for all a in G , $a * e = e * a = a$; and
- iii) For all a in G , there exists b in G such that $a * b = b * a = e$.

Activity. (PLEASE DO NOT TOUCH THE ART WORKS!)

3) Explore the museum looking for artworks that have symmetry. Write down their names/titles and describe the kinds of symmetries you find. Are there any artworks that you really like?

A couple suggestions. i) There's a very mesmerizing painting by Julian Stanczak. Find it. ii) Also, in the contemporary area, Greek-American artist Chryssa's big wall-mounted neon sculpture Americanoom doesn't have the symmetry that her outdoor sculpture Large Metal B has², but we can find some underlying symmetry if we choose to ignore certain features.

4) Why do you think artists (of all times and ages) use symmetry or “break” symmetry??

What kind of feeling do you get when you look at things that are symmetrical and things that aren't? How do you think artists use symmetry and asymmetry to evoke feelings?

²See Sculpture 2. on the last page Extra Credit about Sculptures at UM.

5) Go and take a look at the big white sculpture in front of the Lowe Museum. It's Bovenkamp's *Circles and Waves XX*.

a) What shapes do you see and what kinds of symmetry do these objects have?

b) Guess how many symmetries a circle has.

c) Do you think there's a relationship between circles and waves? ³

d) Can you think of things that aren't cyclical? ⁴

³Waves are described by the *trigonometric functions*, which are defined using the unit **circle**: Let t be any real number and let $P(x, y)$ be the terminal point on the unit circle determined by t . We define

$$\sin t = y; \quad \cos t = x; \quad \tan t = \frac{y}{x} \quad (x \neq 0)$$

and

$$\csc t = \frac{1}{y} \quad (y \neq 0); \quad \sec t = \frac{1}{x} \quad (x \neq 0); \quad \cot t = \frac{x}{y} \quad (y \neq 0)$$

⁴An amazing discovery. In the early 19th century, the mathematical physicist Joseph Fourier showed that periodic functions can be decomposed into a weighted sum of sines and cosines of multiples of the variable. To be more precise: complex-valued functions f of real argument t , $f : R \rightarrow C$, where $f(t)$ is piecewise smooth and continuous, periodic with period T , and square-integrable over the interval from t_1 to t_2 of length T can be decomposed into a weighted sum of sines and cosines of certain multiples of the variable. To learn more about these ideas take a course on differential equations after calculus.