Mathematics of Art

MTH 1220 Spring 2015

Instructor: Stanley Eigen
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Description This is a mathematics course and assorted mathematical concepts will be presented as they apply and appear in works of art - especially that of M.C. Escher. Topics will vary depending upon interests of the students and may include but are not limited to symmetry, finite groups, combinatorics, transformations, frieze patters, wallpaper groups, tessellations, fractals, the fourth dimension and various types of perspective. In addition, we will also study the Cartesian plane, graphing functions, parametric equations, trigonometry and polar coordinates.

Text: We will use a combination of online text (see URL below), youtube videos, and handouts.
`http://math.slu.edu/escher/index.php/Math_and_the_Art_of_M._C._Escher`

Grading: This is a mathematics course and grading will focus primarily on mathematics - though consideration will be given to your art. There will be two in class exams (25% each) and two art/math projects (25% each). There will also be ample opportunity for extra credit projects. Class participation will also be taken into account.

Mathematica and Software: I will be using and demonstrating Mathematica in class. This is a computer algebra system and it will allow me to focus on the mathematics. You are not obligated to learn Mathematica. You may use any software you want. Indeed, you are not required to use any software at all. The projects may be done using any artistic method and materials at your disposal. Note the school has a site license which allows students to download Mathematica onto their own laptops. The school has other software that students have used in the past, Photoshop and Maya for example. These are only on school computers in certain computer labs. The library also has 3D printers and software for producing 3D objects.

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IMPORTANT departmental boiler plate:

1. It is your responsibility to be aware of any changes the instructor may make to the syllabus as they are announced in class, or as posted on the course webpage. Students are responsible for all information given when they are absent.

2. The grade I (Incomplete) will be given only in exceptional circumstances. You must have a passing average on the in class exams; you must have a good attendance record; you must have missed the Final for a good reason. It is University policy that no grade, including an incomplete, can be changed after one year. Exceptions must be authorized by the Academic Standing Committee.

3. Cheating will not be tolerated. All incidents of cheating will be reported to the Office of Judicial Affairs. The University's cheating policy and related disciplinary actions are detailed in the Student Handbook. The Handbook also includes a description of what is considered cheating by the University. Cheating in this class includes (but is not limited to): looking at the papers of others during a quiz or test, talking to other students during a quiz or test.

4. If you have a concern about the course or the instructor that is not or cannot be resolved by speaking with the instructor, contact Professor D. King (the undergraduate director–x5679, donking@neu.edu, 447 LA).

5. The last day to drop a course without a W grade is **Feb 2** The last day to drop a course with a W grade is **April 7** (be sure to inform your instructor).

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Homework #1

1. Download the Mathematica Software to your laptop. Ideally you should have your laptop in class so that you can try the software and begin making your project(s). Note, you can bring your laptop to class and I can help you download the software.

   The software is accessible through myapps, (and a high speed internet connection is recommended).

   Instructions may be found here:

   `http://www.northeastern.edu/its/services/myapps/`

2. Write a one-page note indicating what art, artist, or math you are interested in. (Send e-mail to s.eigen@neu.edu before next Monday.)

   Bridges Math-Art exhibits may be found here:

   `http://bridgesmathart.org/bridges-galleries/art-exhibits/`

   Indicate any software you are familiar with (that might be useful in this course). Examples: Google Sketchup, Geometer's Sketchpad, Photoshop, Gimp, Pov-Ray, Maya

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Project Description

Create/present an **artwork**. *This can mean pretty much anything: painting, sculpture, etc.*
All projects must include a *typed paper explaining and expounding on the mathematics.*
Projects may be solely written papers, computer presentations, poster boards, and of course actual works of art. I am open to other possibilities if you have any ideas (for example, perform and explain some mathematical magic tricks). Group projects are allowed - but you should check with the instructor ahead of time.
You are allowed to use material from the web - but give credit to and include the address where you found the material.
You are allowed to use computer software - but not required. Indicate what software you are using and explain (in simple steps) how you used the software.
Projects may be done in groups - but extra work or necessity is required.
The two projects may be related with the second building and expanding on the first.
Preliminary sketches and work may be handed in with comments explaining thoughts and development

Project Grading

I will be judging the mathematics on accuracy and difficulty. I will be examining the artwork with regard to how it incorporates and reflects the mathematics. I am interested in how well you have mastered the mathematics.
Consideration will be given to quality of the art, choice of materials and originality. (This may be done in consultation with an artist.)

Extra Credit Projects

Presentations and class participation.
Take five pictures of mathematically interesting objects or views (around campus or Boston). Write a brief description of each, indicating where you found it and what it is. This assignment has two goals. First I would like to create a web page with interesting pictures (see "Found Math at the MAA"). Second, I would you like you to become more awareof the mathematics in the world around you. This will be graded on how interesting and original I find your pictures.
Design a walking tour of the campus - explicitly pointing out mathematically interesting objects. The goal is similar to the above. Ditto a walking tour of the MFA.

Project Possibilities

Below are a few suggestions for projects.

If you don't want to think about possibilities then just do the first tessellation project.

You should begin thinking about your projects as soon as possible. Do not hesitate to modify, change and adjust your artwork. Preliminary work may be handed in with your comments and thoughts.

- Escher Style Tessellation.

  Begin with a Motief. What are the symmetries? What decisions did you use in controlling the motief? How does your choice of colors affect the symmetries?

  Create some "supertiles" and tesselations from your motief. Describe the creation of the supertiles. Comment on choices you made. What are the symmetries of the tesselations.

  Make a "recognizable" shape that tiles the plane. First create a shape or an "abstract tile" (polygons) that tiles the plane (you may use existing shapes). How many ways can it tile the plane? Show a few. Discuss the different tilings.

  Next, add colors and interior designs to your shape. Ideally, you want to have a recognizable figure - or two. Discuss how these impact the possibly tilings. Show a few. Discuss the differences and similarities.

  3D-variation. Make a 3D-variation of your tiling. The simplest is a cylinder. Can your tiling be used on a Mobius Strip? Is there an easy adjustment you can make so that it can? (If so, do it)

  -Group variation. If you are working with others, you can decide on a common shape that you all can "design" for different recognizable figures. Which ones "go together"? Make decisions on contrasting colors.

  Advanced variations. Adjust your shape to work as a Spherical or Hyperbolic tessellation.

  Alternately, make a new shape for such a tessellation. (Remember, there is more than one model of the Hyperbolic plane. Choose one or more.)

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- Examine an Artist.

  Choose an artist or artists whose work you enjoy. Make a presentation on their works (you can always change your mind later to a different artist.)

  Discuss the mathematics behind or apparent in the artwork.

  Create new artwork or duplicate existing artwork. Keep a record or your work with an eye toward illustrating the mathematics. If duplicating an artwork try and record your work, illustrating the mathematics with preliminary steps and adjustments.

  The artists listed at http://jmm.submit.bridgesmathart.org/ are currently active. You can contact them and ask them questions (most of them).

  There are many other artists whose work you may find interesting - Search the Web.

  The MFA has works of a number of artists with a mathematical side to the work. Check out Cesar Paternosto, Al Loving, Chuck Close and Josiah McElhney (see also Mirror Mazes).

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- Mathematica Demonstrations. There are many demonstrations concerned with art. Choose a couple and explain the mathematics behind them. (It is not necessary to explain the programming. You may download and use the demonstration in a presentation.)
- Cultural or Historical Tessellations, Wallpaper, Friezes, etc. Present the patterns found in a particular culture or time period. Which patterns, symmetries are present. How are they used. How do the motiefs incorporate color and other designs.
- Tiling with Pentagons. Not all pentagons can tile the plane. Make some 5-sided figures that tile the plane. Discuss etc.
- Aperiodic Tilings. (Penrose tiles for one, but there are many others.)
- Golden Ratio
- Fibonacci numbers
- Platonic Solids
- Chaos and Fractals, Mandlebrot and Julia sets. (Don't just use a program to make pictures. There must be paper with mathematics in it.)
- Picasso, Cubism and the Fourth Dimension
- Penrose Tiles and the Fifth Dimension
- Crop Circles, Straightedge and Compass Constructions, Rope Stretchers
- Perspective: 1-point, 2-point, 3-point, 4-point, 6-point
- One Point Perspective - Create a scene. Create your own scene using the rules of one-point perspective. I expect you to show this in a series of steps - using the formal rules - not just "drawing by eye". Discuss the steps involved.
- Reverse Perspective. Explain angles, vanishing points and geometry. Make your own - take photos with different views.
- Impossible Objects
- Op Art