Mathematics and Digital Art

Instructor:	Dr. Vince Matsko
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Class Times:	TBA
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Website:	www.vincematsko.com
Text:	None required (all readings will be online)
Prerequisite:	Advanced algebra (or above)

Course Description: What is digital art? It is easy to make a digital *image,* but what gives it artistic value? This question will be explored in a practical, hands-on way by having students learn how to create their own digital images and movies in a laboratory-style classroom. We will focus on the Sage/Python environment, and learn to use Processing as well. There will be an emphasis on using the computer to create various types of fractal images. No previous programming experience is necessary.

Learning Outcomes: The following Core Learning Outcomes will be addressed in the course:

1. Students should be able to speak and write effectively.

   Students will be giving three presentations as a part of the course.

2. Students should be able to express ideas in an articulate and persuasive way.

   The students' final presentation will be about their own project work, where they will discuss the significance of their work in the context of the course.

3. Students should be able to understand a mathematical problem and design a solution.

   The students' project work must involve both a mathematical and an artistic component.

4. Students should be exposed to a wide breadth of disciplines, as a foundation for a general liberal arts education.

   Students will be exposed to mathematics, computer science, art, and design throughout the course.

5. Students should appreciate and be able to critically evaluate the arts.

   Throughout the course (and as a part of reading papers and making presentations), we will be addressing the issue of what makes a digital *image* digital *art.* Students will enlarge their vocabulary for articulating their aesthetic views.

6. Students should understand the nature of the physical world, the uses of the scientific method, and the implications of technology.

   In particular, students will engage in hands-on work which will demonstrate the implications of technology in creating works of art.

Also, the specific learning outcomes for mathematics: (students should design a mathematical solution, implement the design or identify and correct problems with the design, and evaluate the validity of a solution and its relevance to the original problem using reasoned discourse as the norm for decision making) will be addressed in the Final Project, where each student must design their own project and give a presentation on it at the end of the semester.

There are also specific learning outcomes for this course in particular:

1. Students should be able to create digital images by adapting Python scripts in the Sage environment.
2. Students should be able to create geometric animations by adapting scripts in the Processing platform.
3. Students should be able recognize and describe different types of fractal images.
4. Students should be able to build three-dimensional polyhedra models given the appropriate polyhedral net.

Schedule of Topics: Note: There are typically 16 weeks in the Fall semester. I outlined 15 weeks, as I would like there to be room for 3–4 guest speakers/excursions during the course of the semester.

Topics broken down by week:

1. Create images based on the work of Josef Albers and *Interaction of Color.* (See my blog post for examples.) Math/CS: linear interpolation, random number generation, introduction to the Python/Sage environment.
2. Create images based on *Evaporation* (see my blog post for an example.) Math/CS: color gradients, basic conditional and looping constructs in Python.
3. Fractals, I: explore fractals defined in a number of ways: Mandelbrot set (complex iteration), L-systems, iterated function systems, etc. Math/CS: relevant mathematics, as well as exploring with the many online applets available for generating fractal images.
4. Fractals, II: Specifically explore fractal images created by the algorithm which produces the Koch curve (see my blog post for examples). The first week will involve geometric series (finding lengths/areas of fractal images), L-systems (Lindenmayer systems), and recursion.

5. Fractals, III: Continuation of the previous week; algorithms necessary to produce fractal images involve number theory – specifically factorization and modular arithmetic.

6. Presentation Week I: The Bridges organization organizes yearly international conferences on the interrelationship between mathematics and art. All papers published in the proceedings from the past 18 years (well over 1000 articles) are available online. Students will give 5–10 minute presentations on one article or two related articles on a topic of their own choosing.

7. Polyhedra I: I have written a textbook on the three-dimensional geometry of polyhedra. Moroever, there are over 50 papers in the Bridges archives on polyhedra (listed here). We will spend two weeks studying the geometry of polyhedra (Platonic solids, Euler's formula), building polyhedra with Zometools, and creating paper models based on the papers in the archive. As time permits, we will also build polyhedra based on modular unit origami.

8. Polyhedra, II. Continuation of the previous week.

9. Processing/Project Work I: This four-week series has two purposes. The first two days of each week will focus on learning the Processing system, which allows the creation of movies from still images (see several examples beginning on October 28 on my Twitter feed, @cre8math). There is a Python environment in Processing, so all the work done previously to learn Python may be used. Students will be taken step-by-step through the process of creating a geometric animation.

   On the third day of each week, students will work on a self-defined project. This is a significant part of the course grade. Students will submit a proposal earlier on in the semester, and will have a chance to revise their proposal before project work begins. The project has room to evolve, so that students may revise their final goal as the project develops.

10. Processing/Project Work II.

11. Presentation Week II: (See the description for Presentation Week I).

12. Processing/Project Work III.

13. Processing/Project Work IV.

14. Final Presentation Week: Students will present the results of their Final Projects. Projects will also be peer-evaluated, and faculty from the mathematics and art/design departments will be invited to attend the presentations.

15. Special topics week: Students will submit ideas about mathematics and art they would like to discuss, and we will spend the two days of the last week exploring some of these topics.

Course components:

1. Attendance: As there will be a significant amount of hands-on work in the course, attendance is required.
2. Presentations: Students will give three presentations – two on course readings, and one on their Final Project. There is an archive from the Bridges conferences of over 1000 short (6–8 pages) papers on mathematics and art. These papers are searchable, so students can look for topics of their own interest for their presentations.
3. Homework assignments: As part of learning how to create digital images, various mathematical ideas are necessary. Students will have occasional problems sets on relevant areas in mathematics (such as number theory and discrete mathematics). Students will also occasionally submit final drafts, with commentary, of work done during laboratory time. Late homework will receive a penalty of 10% per calendar day.
4. Final Project: A student-designed Final Project is a significant part of this course. Approximately mid-semester, students will design an original project of their own incorporating both mathematics and artistic design in a significant way. Some in-class time will be devoted to helping students with their projects. (Note: I wrote a textbook for and designed a project-based course on three-dimensional polyhedra and had great success with this as a culminating assessment for the course.)

There are no exams.

The course components are weighted as follows:

Course component	Percentage
Attendance	15%
Homework assignments	20%
Presentation I	10%
Presentation II	10%
Final Project Proposal	5%
Final Project	30%
Final Project Presentation	10%

Grades will never be lower than the computed average. However, the instructor may raise a grade for exceptional class participation, significant improvement, or particularly brilliant performance within a particular course component.

Withdrawals and Incompletes: The last day to withdraw from the course is Friday, November 6. If you plan to withdraw from the course, it is your responsibility to complete the necessary paperwork by this date. You will not be allowed to withdraw after this date. An incomplete grade will be given only if you have a serious emergency, such as a medical condition, that prevents you from completing the course. You must produce proper documentation and must be passing the course with most of it complete. An incomplete grade will not be granted to avoid failing the course.

Academic Honesty: As a Jesuit institution committed to cura personalis – the care and education of the whole person – USF has an obligation to embody and foster the values of honesty and integrity. USF upholds the standards of honesty and integrity from all members of the academic community. All students are expected to know and adhere to the University's Honor Code. You can find the full text of the code online at www.usfca.edu/fogcutter. You are encouraged to discuss the homework problems and course material with other students and with me during office hours. However, the homework that you hand in should reflect your own understanding of the material. You are NOT allowed to simply copy solutions from other students or other sources.