

Math 193.2 Fractals and Nature
Spring 2007

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Course Materials – The basic text is the online book *Fractal Geometry* by Frame, Madelbrot, and Neger. This book may be found at <http://classes.yale.edu/fractals/>.

Course Goals – In this course you will explore fractal geometry and how it relates to the world around us.

Evaluation and Grading – Grades will be the result of homework, labs, one midterm exam, and a cumulative final exam. The breakdown is as follows:

Culture Points – 5%

Labs/Homework – 40% total

Exam – 25%

Final Exam – 30%

Attendance – Regular attendance is vital. A late assignment will be graded with a reduction of 20% for each day it is late. There will be no make-up quizzes given, and make-up exams are given only in extreme, pre-approved cases. If you have to miss an exam it is your responsibility to contact me in advance.

Disclaimer – This syllabus is subject to change through the semester. Any updates to the syllabus will be announced in class.

Learning Disability Accommodations – Students who have documented learning disabilities and wish to request accommodations for this class should contact Mrs. Laurie Roth, Director of Learning Services. Accommodations cannot be provided unless official documentation is received from the appropriate campus office.

Mathematics Department Academic Honesty Policy – The Mathematics Department supports and is governed by the Academic Honesty Policy of Moravian College as stated in the Moravian College Student Handbook. The following statements will help clarify the policies of members of the Mathematics Department faculty.

In all at-home assignments which are to be graded, you may use your class notes and any books or library sources. When you use the ideas or thoughts of others, however, you must acknowledge the source. You also may not use a solution manual or the help (orally or in written form) of any individual other than your instructor. If you receive help from anyone other than your instructor or if you fail to reference your sources, you will be violating the Academic Honesty Policy of Moravian College. You may work with your fellow students on homework which is not to be graded. You are responsible for understanding and being able to explain the solution of all assigned problems, both graded and un-graded.

All in-class or take-home tests and quizzes are to be completed by you alone without the aid of books, study sheets, or formula sheets unless specifically allowed by your instructor for a particular test.

Culture Points: Exploring the nature of mathematics

The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful. If nature were not beautiful, it would not be worth knowing, and if nature were not worth knowing, life would not be worth living. Of course I do not here speak of that beauty that strikes the senses, the beauty of qualities and appearances; not that I undervalue such beauty, far from it, but it has nothing to do with science; I mean that profounder beauty which comes from the harmonious order of the parts, and which a pure intelligence can grasp.

Henri Poincaré

The mathematician's patterns, like the painter's or the poet's must be beautiful; the ideas, like the colours or the words must fit together in a harmonious way. Beauty is the first test: there is no permanent place in this world for ugly mathematics.

G. H. Hardy

To those who do not know mathematics it is difficult to get across a real feeling as to the beauty, the deepest beauty, of nature . . . If you want to learn about nature, to appreciate nature, it is necessary to understand the language that she speaks in.

Richard Feynman

One goal for this class is to provide some perspective of mathematics, and the role it plays in our modern world. Whether you plan to be a mathematician, a scientist, or simply a well-rounded liberal arts graduate, it is important to be aware of the role and nature of mathematics today. To help meet this goal, I am asking you to participate in “mathematical cultural awareness.” There are no specific assignments for this portion of the course. Rather, there are many opportunities for you to explore mathematics in our culture. Activities that foster cultural awareness include (but are not limited to): attending talks, discussing a mathematical topic with a fellow student or professor, giving a talk, reading a paper, or solving a problem.

Basic overview of culture points

Culture points activities will account for 5% of your final course grade. To get full credit for this activity, you must accrue **10 points** by the end of the semester. You gain points by attending seminars, colloquia or other talks; discussing mathematics outside class; reading articles; giving presentations; solving problems.

To get credit for an event, you will need to submit a short write-up for the event. This write-up will have two portions: (1) a short description of the event and (2) a reflection on the impact of that event on your own understanding of mathematics.

Points will be given based both on the quality of the event and the quality of the submission. The following sections provide details on this activity.

Culture point activities

The fact is that there are few more “popular” subjects than mathematics. Most people have some appreciation of mathematics, just as most people can enjoy a pleasant tune; and there are probably more people really interested in mathematics than in music. Appearances may suggest the contrary, but there are easy explanations. Music can be used to stimulate mass emotion, while mathematics cannot; and musical incapacity is recognized (no doubt rightly) as mildly discreditable, whereas most people are so frightened of the name of mathematics that they are ready, quite unaffectedly, to exaggerate their own mathematical stupidity.

G. H. Hardy

This list below is not comprehensive – it is meant to illustrate some possible activities and to provide a calibration for how many culture points different activities might provide. Note that the actual number of culture points you get will vary depending on the quality of your particular write-up.

- Attend an ϵ -talk (3 points)
- Attend a Math/CS colloquium (4 points)

- Attend a colloquium or conference off-campus (5 to 10 points). There are many opportunities to attend conferences throughout the valley, such as at Lafayette or Lehigh.
- Review an article on mathematics (3 to 10 points). I have attached a listing of places to look for articles, as well how many points you might get for different articles. Also look to sources such as the *New York Times*, the *Washington Post*, or PBS for mathematics in the news.
- Discuss a mathematical topic with someone outside the class (2 to 6 points) – this could be with roommates, teammates, family members, other professors. You can discuss a mathematical topic from the course or some other mathematical topic.
- Find mathematics in popular culture (2 to 4 points) – episodes of *NUMB3RS*, movies such as *A Beautiful Mind*, or references in *The Simpsons*. Also look for mathematics in the creation of movies by Pixar, Lucas-Films or Dreamworks.
- Work on a problem outside the scope of the classroom (4 to 10 points). You might solve an interesting exercise or simply work on an interesting problem without quite reaching a solution.

Before submitting your culture-points write-up, consider some ways of bolstering the number of points your submission will be worth:

- If you give a short (5 to 10 minute) oral presentation of you culture points activity, you will get additional points for your write-up. You can gain an additional 3 points by presenting your activity in class or 7 points by presenting your activity as an ϵ -talk.
- For an additional 2 points, you may submit the culture points article to me during office hours so that we might spend a few minutes discussing the activity one-on-one.
- You can follow up on activities for a more robust submission. In this way, you can combine two or more culture point activities into a single write-up. Some examples:
 - After attending a colloquium, you may return to your dorm and discuss the event with your friends over pizza. Your write-up will then discuss both the colloquium and the conversation on mathematics, giving you credit for both.
 - After watching an episode of *NUMB3RS*, go the “We all do math everyday” website associated with the show and look up the mathematics involved in that episode. Most of the worksheets on the site provide references for more information. Follow one of those references before you submit your write-up and gain credit for the show and the article reading.
 - A culture point activity (article, talk, or some other event) may have piqued your interest in a mathematical problem. Spend some time working on that problem and your write-up can include some of your own insights on the problem.

Rules for submission

Your culture point write-up must be neat and well-written (complete sentences, paragraph structure, etc.). I prefer your submissions to be typed, but I will accept hand-written submissions – particularly if there is a great deal of mathematical notation. For each submission, keep in mind that there are two portions:

1. **Summary of the event:** This section of the write-up should constitute no more than 50% of your submission. Summarize the talk, conversation, article, or event. If you were working on a problem, discuss *how* you approached the problem and whether you were able to arrive at a satisfactory answer (provide the actual solution or work on the problem on an attached page)

2. **Reflection on the event:** How does the event affect your understanding of mathematics and mathematicians? Do you have a greater appreciation of the role of mathematics in society or the nature of mathematical research? Does the event connect with the mathematics you've learned in this course (or any of your other mathematics courses)? If you worked on a problem, explain how your work on that problem has influenced the way you solve problems or your understanding of the mathematics involved.

Be sure to clearly state what the involved event was. If you watched an episode of a series, be sure to include the name of the episode as well as the name of the series. If you read an article, include a full citation of the article (do NOT include a copy of the article itself). If you attended a talk or seminar, include the name of the talk and of the speaker.

Miscellaneous rules

- You may make at most one culture point submission per week. Any single culture point submission can be given a maximum of 12 points.
- At least one culture point submission needs to be based on a talk, colloquium or seminar. At least one culture point submission needs to be based on an article or reading.
- Culture point submission that do not follow the above rules (particularly regarding neatness and making full citations) will be penalized or rejected.
- Culture points above the required number will be used as “extra credit” – how extra culture points translate to bonus points on the final grade will be determined at the end of the semester.

It is not knowledge, but the act of learning, not possession but the act of getting there, which grants the greatest enjoyment. When I have clarified and exhausted a subject, then I turn away from it, in order to go into darkness again; the never-satisfied man is so strange if he has completed a structure, then it is not in order to dwell in it peacefully, but in order to begin another. I imagine the world conqueror must feel thus, who, after one kingdom is scarcely conquered, stretches out his arms for others.

Karl Friedrich Gauss

Places to go for articles and other writings

Books and Journals

- (3 to 5 points) – mathematical articles from popular journals such as *Popular Science*, *Scientific American*, or *National Geographic*
- (3 to 5 points) – teaching-oriented journals such as *Mathematics Teacher* or *Mathematics Teaching*
- (4 to 10 points) – articles from journals such as *American Mathematical Monthly*, *The College Mathematics Journal*, *Mathematics Magazine*, or *PME Monthly*. Many of these journals can be found in JSTOR and are available both in Reeves and the the Mathematics library.
- (3 to 8 points) – many books provide terrific insight to the nature of mathematics. Pick a chapter of almost any of the general mathematics books by Martin Gardner, Ian Stewart, Sherman Stein, or Keith Devlin.

There are many other interesting articles out there – look through some of the search engines available through Reeves to discover articles on your own.

Math in the news

Look through the newspapers, especially the *New York Times*, the *Chicago Tribune* and other major newspapers for articles on mathematics in modern culture.

You can also find mathematics on the History Channel, the Discovery Channel, or PBS.

Consider almost any topic: the war in Iraq, football, jazz music, security at the airports, global warming, sink-holes, overpopulation, Windows Vista, poker. If you search through the web facilities available in Reeves, you can find an article connecting your favorite activity to mathematics.

Web Resources

Below are just a few links to mathematical articles (and a rough indication of their point value)

- <http://www.maa.org/news/columns.html> (2 to 6 points)
There is a host of columns here – all quite readable. Be sure to look through the archives to find articles of particular interest.
- <http://www.americanscientist.org> (2 to 4 points)
While most articles are more for the sciences, there are a few mathematics articles that get thrown in. Two of the more recent articles are *Unwed Numbers: The Mathematics of Sudoku, a puzzle that boasts “No math required!”* and *Group Theory in the Bedroom: An insomniac’s guide to the curious mathematics of mattress flipping*.
- <http://www-groups.dcs.st-and.ac.uk/~history/> (3 to 5 points)
Look up a mathematician or mathematical topic here for a historical perspective on the mathematics you are learning. Start with those mathematicians that are mentioned in class (so who is that Simpson guy behind Simpson’s rule for integration?).
- <http://www.cut-the-knot.org> (4 points)
Lots of interesting mathematical tid-bits, most of which include an interactive applet for you to experiment with.
- <http://plus.maths.org/> (4 to 6 points)
An on-line magazine devoted almost exclusively to questions in the mathematical sciences.