Optimal Geometry in Nature, Art, and Mathematics

TC 310: Modes of Reasoning — Unique Number 43550

Spring 2010

"Equations are just the boring part of mathematics. I attempt to see things in terms of geometry." — Stephen Hawking

Course description

The objectives of this course are to help students explore some of the ways in which mathematicians think about the natural world — specifically, how their ways of understanding mathematics and the natural world inform and interact with each other. We will do this through four "case studies", organized around the following topics:

(1) Optimality and Minimal Surfaces;
(2) Pattern and Abstraction;
(3) Evidence and Proof; and
(4) Symmetries and their Structure.

Basic information

Class location: WEL 3.402
Class times: 2:00–3:30 Tuesdays and Thursdays
Instructor: Associate Professor Dan Knopf
Email: `danknopf@math.utexas.edu`
Homepage: `http://www.ma.utexas.edu/users/danknopf`
Office: RLM 9.152
Phone: 471.8131
Office hours: 10:00–12:00 Mondays, and by appointment
Syllabus: This syllabus/first-day handout will be updated during the semester. A current version will always be available on BLACKBOARD as well as through a link from the home page above.
Accommodations: Students with disabilities should request appropriate academic accommodations from the Division of Diversity and Community Engagement, Services for Students with Disabilities. Visit `http://www.utexas.edu/diversity/ddce/ssd/` or else call 471.6259. (Please inform me of any approved accommodations as early in the semester as possible.)

Course materials

Doing the readings is a vital component of success in this course.

Our main source will be *The Parsimonious Universe: Shape and Form in the Natural World*, by Stefan Hildebrandt and Anthony Tromba. It is available (used) from the Co-op.

Various supplemental readings are collected in a custom course packet, also available from the Co-op. Its readings are excerpted from the following:

- *Architecture and Geometry in the Age of the Baroque*, by George L. Hersey;
- *Connections: The Geometric Bridge between Art and Science*, by Jay Kappraff;
- *Fearful Symmetry: Is God a geometer?*, by Ian Stewart and Martin Golubitsky;
- *Geometry of Design: Studies in Proportion and Composition*, by Kimberley Elam;
- *Life's Other Secret: The New Mathematics of the Living World*, by Ian Stewart;
- *On growth and form*, by D'Arcy Wentworth Thompson; and
- *The shape of space*, by Jeffrey R. Weeks.

Grading policy

You should not expect to succeed in this course without regular attendance and active participation.

Your final grade will be based on the following components:

- Four in-class exams, each worth 20% of the total grade. (See below.)
- Regular homework assignments, collectively worth 10% of your grade.
- Class participation, worth 10% of your grade. (You will complete daily "minute papers" — brief paragraphs written in response to questions raised during class discussion.)

There will be no final exam.

Your overall grade will be computed using the following scale:

D-	D	D+	C-	C	C+	B-	B	B+	A-	A
51–55	56–63	64–65	66–67	68–75	76–77	78–79	80–87	88–89	90–91	92–100

Course schedule

The following is only a broad outline of the course schedule. Exact dates and contents of assigned readings, homework due dates, *et cetera*, will be announced as the course progresses. The schedule may also be changed for pedagogical reasons. It is your responsibility to be aware of any changes announced in class.

Prologue: *Weeks 1–2*
  (January 19, 21, 26, 28)
  - Motivation and introduction
  - Read Prologue and Chapter 3 (excerpts) from *Parsimonious*.

Optimality and Minimal Surfaces: *Weeks 3–5*
  (February 2, 4, 9, 11, 16, 18)
  - Read Chapters 5 and 6 (excerpts) from *Parsimonious*.
  - Read excerpts from *The shape of space*.
  - **Exam I: February 18**

Pattern and Abstraction: *Weeks 6–8*
  (February 23, 25; March 2, 4, 9, 11)
  - Read excerpts from *Geometry of Design*, *Life's Other Secret*, and *On growth and form*.
  - **Exam II: March 11**

Spring Break: *(March 15–20)*

Evidence and Proof: *Weeks 9–11*
  (March 23, 25, 30; April 1, 6, 8)
  - Read Chapters 1–2 from *Parsimonious*.
  - Read excerpts from *Connections*.
  - **Exam III: April 8**

Symmetries and their Structure: *Weeks 12–14*
  (April 13, 15, 20, 22, 27, 29)
  - Read excerpts from *Architecture and Geometry* and *Fearful Symmetry*.
  - **Exam IV: April 29**

Epilogue: *Week 15*
  (May 4, 6)
  - Preparation of final projects

Other important dates: February 15 is the last day to drop without possible academic penalty; March 29 is the last day to drop except for urgent non-academic reasons.