Project ideas: Math 1060-300, Fall 2020

- It is sometimes said that "there are only 17 types of wallpaper". This is a statement about the possible ways to tile the plane, up to symmetries. These are especially used in Islamic patters. For example, the Alhambra in Spain, exhibits 13 of these patters, and the mathematician Branko Grünbaum has claimed that the other 4 are found nowhere in Islamic art. Incidentally, there are only "7 types of friezes", i.e., patterns that repeat in only one direction.
- In a similar spirit to the previous topic, a *Penrose tiling* is a remarkable way to tile the plane in a non-repeating fashion, using two basic shapes, which are quadrilaterals called "kites" and "darts". Moreover, there are infinitely many distinct ways to do this. Not surprisingly, these patters have appeared in a number of artistic and architectural works. These are named for Sir Roger Penrose, a Nobel Laureate in Physics. He also came up with the *Penrose triangle*, an impossible figure, much like what M.C. Escher is known for.
- Building off of the previous topic, everyone knows that M.C. Escher was a famous artist, and much of his work involves a synergy between math and architecture. He collaborated and corresponding with Roger Penrose, and both of them have contributed to the other's ideas.
- In addition to aperiodic tilings such as Penrose tilings appearing in modern architecture, fractal geometry has as well. The 2012 book *Fractal Architecture: Organic Design Philosophy in Theory and Practice*, is freely available online through the Clemson Library. There are a number of topics that can be chosen from this book.
- A *hyperboloid* is a solid of revolution generated by rotating a hyperbola around a principal axis. Hyperboloid structures are buildings or towers that are designed in this shape. The first one was built in the late 1800s. One project would be to give an overview of this – both the underlying mathematics and a brief history of these building from the 1800s to the modern day.
- Buckminster Fuller was an American architect and inventor, who popularized the geodesic dome. A good deal of his work involves interesting mathematics and symmetry. The buckminsterfullerene molecule C_{60} is named after him, and is informally called the buckyball.
- In Hahn's book, Chapter 3: *Architecture Inspired by Faith*, has the following small subsections.
  - Splendors of Islam
  - Romanesque Architecture
  - Soaring Gothic
  - From the Annals of a Building Council (Milan)
  - The Magic of Venice and Pisa

  Pick several of these to discuss. Both the historical context, architectural significance, and basic mathematical properties.
- Much of Chapter 4 of Hahn's book, *Transmission of Mathematics and Transition in Architecture*, is an introduction to mathematical ideas and their historical context, such as conic sections, axiomized geometry, and number systems, and coordinate geometry. However, it ends with a specific example that brings together some of these idea:
  - *The Duomo of Florence* (pp. 118–126)
- Chapter 5 of Hahn's book, *The Renaissance: Architecture and the Human Spirit* is very long (50 pages), and there are a number of topics within there that would make for a good project.
  - The sections *Brunelleschi and Perspective* (p. 172–179) and *From Circle to Ellipse* (pp. 179–187) are both about the mathematics of perspective in architecture. Either of these individually would be a decent topic, and not nearly in as much detail as is in Hahn.
- We covered the first half of Chapter 6 of Hahn's book: *A New Architecture: Materials, Structural Analysis, Computers, and Design*, but not the second part.

  - *Analyzing Structures: Statics and Materials* (pp. 226–233)
  - *The Sydney Opera House* (pp. 233–248)
  - *Computers, CAD, CAM, and the Guggenheim Museum in Bilbao* (pp. 248–256)
- Sebastiano Serlio (1475–1544) was an architectural theorist, and he published *Five Books of Architecture*, on geometry and perspective, drawing from both ancient Roman and modern Renaissance works. There is a bit of this in the *Problems and Discussions* in Chapter 5 of Hahn.
- Propose your own!