

**Math, Music, and Art**  
**HNRS 3900 – 3 credit hours**  
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**University Honors Program**  
**Philip Harold and Monica VanDieren, Co-Directors**

**Course Description:**

Instead of considering the mathematics underlying sound and digital media, this course takes a novel approach to the cross-fertilization of ideas between mathematics, music, and art. The course is structured around four themes common to mathematics, music, and art with the overarching goal that the students will understand the creative process as it applies not only to these but also to other disciplines. Selected examples depicting the four themes (symmetry, infinity, search for truth and self, and improvisation) slant toward the nineteenth and twentieth centuries, culminating in the avant-garde movement and development of the digital computer. Class enrollment: 15 students.

**Primary Text:**

Doxiadis, A., & Papadimitriou, C. (2009). *Logicomix: An Epic Search for Truth*. New York: Bloomsbury.

**Required reading of selections from:**

Beerbohm, M. (1916, May). Enoch Soames. *The Century Magazine*. Available at <http://www.gutenberg.org/ebooks/760>.

Brewster, G. (Ed.). (1985). *The Creative Process*. University of California Press.

Euclid, (1847). *Elements of Geometry*. Byrne, O, (Ed.). Available at: <http://www.math.ubc.ca/~cass/euclid/byrne.html>.

Mancosu, P. (2011). Book Review: *Logicomix* by Apostolos Doxiadis, Christos H. Papadimitriou, Alecos Papadatos, and Annie di Donna. *The Journal of Humanistic Mathematics*, 1 (1), 137-152.

Milton, B. (1958, February). Who Cares if you Listen? *High Fidelity*.

Strogatz, S. (2010, April 4). Take It to the Limit. *New York Times*. Available at: <http://opinionator.blogs.nytimes.com/2010/04/04/take-it-to-the-limit/>.

## Syllabus:

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| <p><b>Weeks 1 and 2<br/>History</b></p>                               | <p><i>People:</i> Aristotle, Pythagoras, Plato, Zeno, Euclid, Archimedes<br/> <i>Topics:</i> Trivium and Quadrivium, Golden Ratio, Elements of Music (tone, whole step, rhythm, etc.), Elements of Mathematics (axioms, theorems, proofs, etc.)<br/> <i>Class activity:</i> Explore logical relations, conjectures and proofs using the card game <i>Set</i><sup>TM</sup>.<br/> <i>Assignment:</i> Students are assigned to read part of Euclid's Elements illustrated by Byrne and give a short presentation of their selection to the class.<br/> <i>Logicomix reading:</i> Parts 1-3</p>  |
| <p><b>Week 3<br/>Symmetry<br/>Introduction</b></p>                    | <p>Introduced from the mathematical perspective, visualized in art examples.<br/> <i>Topics:</i> Dihedral symmetry, non-Abelian symmetry, frieze patterns, planar patterns, 17 wallpaper symmetries, Islamic art, Hungarian needlepoint, architecture.<br/> <i>Class activity:</i> Cut out a Penrose triangle, compare to Escher woodcut.<br/> <i>Assignment:</i> Complete a group of symmetries and photograph an example of one of the symmetric groups on campus</p>  |
| <p><b>Weeks 4-6<br/>Symmetry in<br/>Music</b></p>                     | <p><i>Topics:</i> balance in Mozart, diatonic scale, triads, circle of fifths, Neo-Riemannian transformations <math>P</math>, <math>L</math>, and <math>R</math>; tonnetz. <math>PLR</math>-group is a dihedral group of order 24 generated by <math>L</math> and <math>R</math>, exemplified in Beethoven's Ninth Symphony, pitch class set theory, serialism, maximalism, atonal music, Schoenberg, Babbitt, grids/matrices<br/> <i>Class Activity:</i> Ball toss to demonstrate the construction of the circle of fifths.<br/> <i>Assignment:</i> Find an example of music that exhibits symmetry or balance to share with the class.<br/> <i>Assignment:</i> PLR worksheet<br/> <i>Assignment:</i> musical matrix worksheet<br/> <i>Quiz</i> on people and terminology from the History and Symmetry classes and readings.</p> |
| <p><b>Week 7<br/>Infinity from a<br/>mathematician's<br/>view</b></p> | <p><i>Topics:</i> Infinity from the point of view of Zeno, Aristotle, Euclid's Principle, Galileo, Leibniz, Newton, Bolzano, Cantor, Gödel &amp; Cohen. Paradoxes involving infinity. Aside about Fourier analysis and its role in digital music. Power set, different sizes of infinity, Hilbert's Hotel<br/> <i>In-class activity:</i> Construct a clay model to visualize <math>\mathbb{N} \times \mathbb{N} \times \mathbb{N}</math><br/> <i>Assignment:</i> infinity worksheet and read "Take it to the Limit"<br/> <i>Logicomix reading:</i> Parts 4-5</p>   |
| <p><b>Week 8<br/>Infinity and Art</b></p>                             | <p><i>Topics:</i> Potential and actual infinity of Aristotle, perspective, God, Thomas Aquinas metaphor of a circle representing eternity. Experimentation with visual interpretations of infinity as seen in Christian iconography, cubists, surrealists, and other artists such as Rothko, Pollock, Kandinsky, Mondrian, Picasso, Braque, Magritte, Beaver, Estes, and Bansky.</p>   |

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| <p><b>Week 9<br/>Infinity in<br/>Music and the<br/>Sublime</b></p> | <p><i>Topics:</i> Experimentation with time and pitch as “infinite” with Harry Patch, John Cage, Stockhausen, Paul Lansky, Max Neuhaus. Just temperament vs equal temperament, harmonics, audio illusions with Shepard tones. Infinity as part of the sublime: William Turner, Ansel Adams, Henryk Górecki.<br/><i>Assignment:</i> Listen to Samuel Barber’s “Adagio for Strings” and write a one-page response to the <i>sublime</i> as you hear it in this piece.<br/><i>Quiz</i> on people and terminology from the Infinity classes and readings.</p>   |
| <p><b>Weeks 10-11<br/>Searching for<br/>Truth and Self</b></p>     | <p><i>Topics:</i> Fractals and self-similarity, Russell’s Paradox, other paradoxes including Liar’s, Banach-Tarski, Simpson’s, Smale’s etc. Magritte’s Treachery of images, Kosuth’s “One and Three Chairs.” Examples from literature: <i>Tristram Shandy</i>. Minimalism in art and music with examples from Steve Reich, John Adams, Philip Glass. <i>Einstein on the Beach</i>.<br/><i>In-class activity:</i> Fractal origami<br/><i>Assignment:</i> Fractal worksheet<br/><i>Assignment:</i> Read “Enoch Soames” and discuss self-reference in this and other pieces of literature.<br/><i>Logicomix reading:</i> Part 6 and <i>Logicomix</i> review by Paolo Mancosu</p> |
| <p><b>Week 12<br/>Improvisation</b></p>                            | <p><i>Topics:</i> Paul Berliner’s formal structure of improvisation (essentially improvisation is conversations with history/tradition, with self, with other players, with the audience, with models of formal composition). Jazz history, compositional elements, and improv in the visual arts. The development of the modern computer (from Euclid to Turing) as viewed through Berliner’s improvisation paradigm.<br/><i>Quiz</i> on searching for self/truth and improvisation.</p>   |
| <p><b>Weeks 13-15<br/>Student<br/>presentations</b></p>            | <p>Students present their Creative Projects. One group applied mathematical transformations to create a new arrangement of Pachelbel’s Canon in D which they performed for the class. One group compiled and explained mathematical and artistic representations of the internet. Another student conducted a Neo-Reimannian analysis of John Williams’ music and created an animation of the tonnetz which she shared with the class.</p>  |
| <p><b>Take-home<br/>Final</b></p>                                  | <p>Students selected two to three articles from <i>The Creative Process</i>. Their task was to reflect upon how the creative process is used in math, music, and art and in their major/career choice by drawing upon examples from class, the readings, and external sources. One student wrote his entire final as a poem.</p>  |

**Co-curricular activities:**

- HNRS 3900 students presented Escher’s influence on the movie *Inception* for the entire University Honors Program student body.
- Field trip to the Akron Museum of Art to see M.C. Escher’s traveling exhibit.
- Guest performance and presentation by touring musician and audiophile Nathaniel Bartlett. Bartlett uses mathematical and computational components to create music in a 3-dimensional environment.
- HNRS 3900 students attended the campus-wide panel discussion led by members of the Pittsburgh Symphony Orchestra on The Business of Music.

**Grading:**

| <b>Type of Assessment</b>           | <b>Percentage of Course Grade</b> |
|-------------------------------------|-----------------------------------|
| Quizzes                             | 20                                |
| Homework and in-class participation | 20                                |
| Creative project                    | 40                                |
| Final Exam                          | 20                                |

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