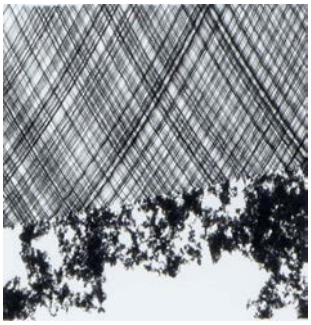
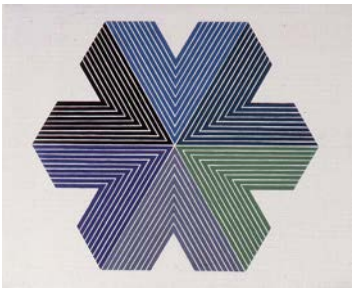
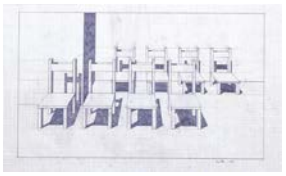
Visualizing Math










ADDISON
Addison Gallery of American Art

This Portfolio Guide contains selected artworks and ideas to connect the Addison's collection with classroom themes, disciplines, and curricula.

Digital images of works from this Guide can be downloaded from the Addison's website for use in classrooms. Visits to explore works in the Addison's Museum Learning Center can be arranged as a complement to the viewing of current exhibitions.

www.addisongallery.org

How can art be used to investigate and visualize mathematical problems and systems?

How can mathematical principles help us to understand the construction of an image and the representation of the world around us?

Just as many artists find inspiration in math, from sequences to symmetry, mathematical principles can help us to understand both artwork and representations of the world around us. This ***Permanent Collection Portfolio Guide*** of prints, drawings, and paintings features a sampling of the Addison's collection offering varied perspectives and discussion points on topics in mathematics. Educators are encouraged to use this Guide and the expanded ***Portfolio Image List*** as a starting point, a place from which to dig deeper, ask questions, and make new connections for class plans and projects.

Images and text highlighted in grey are ideas for materials and activities from outside the Addison's collection of American art that can enhance the potential for both curricular and global connections.

For online use, click the images in this guide to access digital images in the Addison's online database.

SELECTED THEMATIC APPROACHES

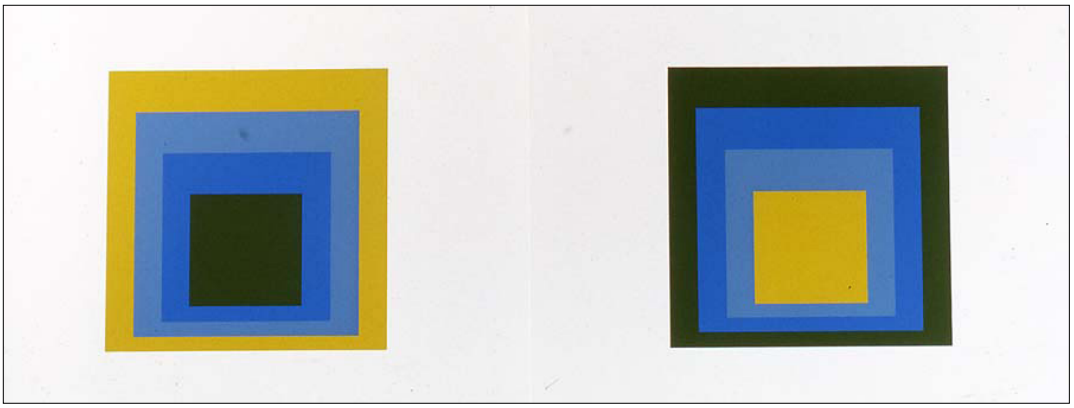
Minimalism and Manipulations – How can images demonstrate relationships between parts of a whole?
Process, Scale, and Probability – How do artists construct and follow formulas, algorithms, and iterations?
Perspective, Depth, and Similarity – How can math be used to understand relationships between objects?
Analyzing the Collection by the Numbers – How can combinatorics help us to understand a museum's collection?
Systems, Order, and Randomness – How can art and music be inspired by the aesthetic simplicity of math, physics, and code?

A Josef Albers (1888-1976), *Formulation: Articulation I, Folder 5*, from series *Formulation: Articulation I*, 1972, screenprint on paper, 15 x 40 in., gift of The Josef Albers Foundation, 1975.41.5, © 2006 The Josef and Anni Albers Foundation/ Artist Rights Society, New York

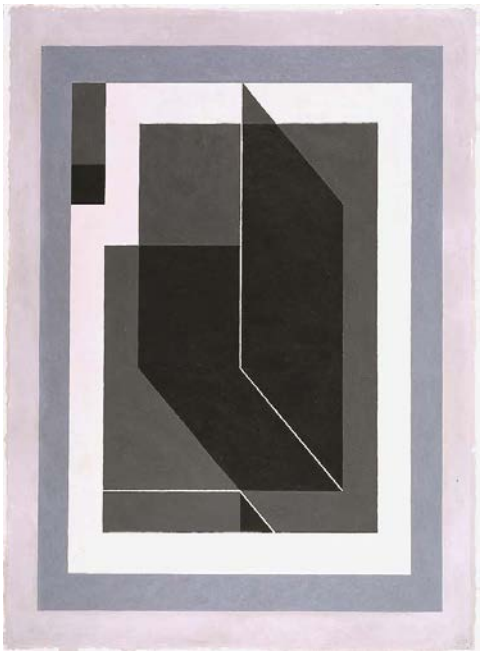
B Josef Albers (1888-1976), *Bent Black (A)*, 1940, oil on masonite, 37 1/2 x 27 3/4 in., gift of Mrs. Frederick E. Donaldson, 1944.11

C Frank Stella (b.1936), *Star of Persia II*, April 1967, lithograph on English graph paper, 26 x 32 in., museum purchase, 1967.8, © Frank Stella

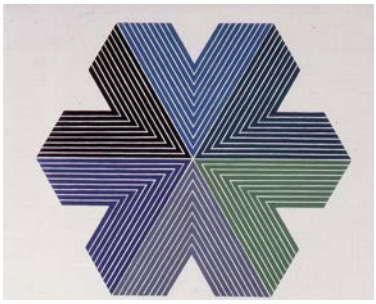
D Robert Mangold (b.1937), *Distorted Square Within a Circle 3*, 1973, serigraph on Arches 88 paper with natural edge on left and deckle at lower edge, 20 1/8 x 20 1/8 in., gift of the artist, 2002.57.3



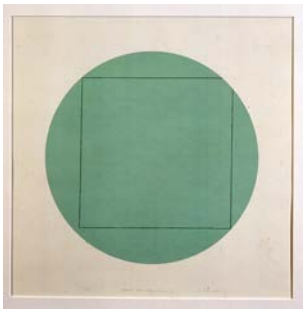
A



B



C



D

Connected Activities:

Transformation and Symmetry: How can we use these concepts to understand the composition of an image?

Area and Perimeter: How are these measurements impacted when a shape doubles or triples in size?

Describe what you see: What vocabulary can we use to describe both art and math? Think about parallelism, dimension, infinity, simplification, scale, etc.

Minimalism and Manipulations

In what ways is math, like art, sometimes concrete and other times an abstract subject? When do we follow the rules and when is experimentation more important than precision?

How can images demonstrate relationships between parts of a whole?

In the mid 20th century, educator and artist **Josef Albers**'s experimentation with color interaction and geometric shapes transformed the modern art scene. His nested squares examine the way adjacent colors expand and contract, recede or advance. His painting *Bent Black* also tests viewer perception, with precisely equal areas of each color: black, dark gray, light gray, and white. By the time artist **Frank Stella** entered Phillips Academy as a student in 1950, the art department was imbued with philosophy brought in by teachers who had studied with Albers at Yale. Stella's early work is built on relationships between lines and planes, and characterized by order and simplicity.

In the 1960s, Minimalism emerged as an alternative to the emotionally charged gestures of Abstract Expressionism and artists developed images in simplified visual sequences, like mathematical proofs. The work of **Robert Mangold**, for example, is inspired by geometry and asymmetry; his visual "mistakes" push geometry askew, along with viewers' perceptions of his work.

E-H by Sol LeWitt (1928-2007)

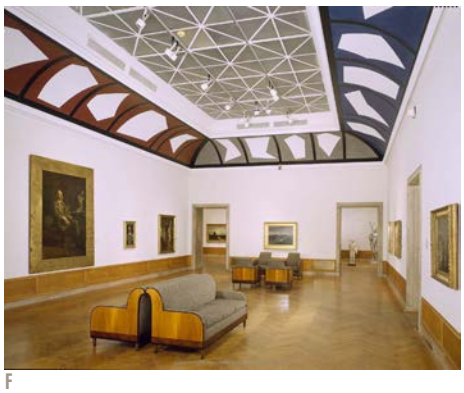
E *Fifteen Postcards,* 1976, fifteen postcards with color inks mounted on board, gift of Lucy Lippard (AA 1954), Addison Art Drive, 1991.80, © 2014 The LeWitt Estate / Artists Rights Society (ARS), NY.

F INSTALLATION: *Wall Drawing #713: On a vaulted ceiling, 20 irregular five-sided figures.,* January 1993, color ink wash and India ink, gift of the artist, 1993.49, © 2014 The LeWitt Estate / Artists Rights Society (ARS), NY., Addison Gallery of American Art

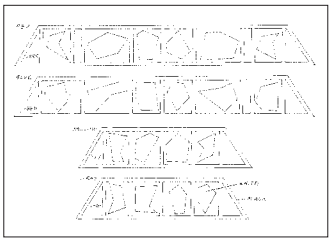
G DETAIL: Diagram for *Wall Drawing #713*

H INSTALLATION: *Wall Drawing #716:* A 12" (30 cm) grid covering the black wall. Within each 12" (30 cm) square, a straight vertical, horizontal, diagonal right or diagonal left line or an arc from one of the four corners bisecting the square. All squares must be filled by one of the 8 choices. The direction or kind of arc or line in each square is determined by assigning each possibility a number (1 - 8) and by having the drafts(wo) man pull those numbers 1-8 out of a hat. The drawing must begin with the upper left module, and end with the lower right., black wall, pencil grid, and white crayon arcs and lines, gift of Carl Andre (PA 1953), 1993.50, © 2014 The LeWitt Estate / Artists Rights Society (ARS), NY., Addison Gallery of American Art

E



F



G

H

Connected Activities:

Ratio and Scale: Scale a LeWitt diagram onto large sheets of paper.

Probability: What is the probability of drawing a complete circle in *Wall Drawing #716*?

Combinations and Permutations: How many wall drawings could result from the eight lines of *#716*?

Graphing: Which lines show functions that are increasing, decreasing, concave up, or concave down?

Process, Scale, and Probability

How can art be used to investigate and visualize mathematical problems?

In what ways is the conceptual artist's role similar to that of an architect? a composer? a mathematician?

Sol LeWitt was prominent among a group of young artists who, in the 1960s, were searching for alternatives to traditional constraints. His 1975 work *Fifteen Postcards* is made of actual postcards sent through the U.S. postal system over a period of fourteen days. Here, LeWitt presents all possible combinations of yellow, black, red, and blue: first, each color standing alone, then six different two-part combinations, followed by four different three-part combinations, and the final postcard with all four colors combined.

LeWitt was an influential practitioner of Conceptual Art, in which the artist is the originator of the ideas, rather than the craftsman. Each of LeWitt's Wall Drawings begins as a set of instructions and an accompanying diagram to be followed by draftspeople in implementation. Just as a music composition sounds different each time it is played due to acoustics and interpretation by the musicians, the potential for variation in LeWitt's Wall Drawings is exemplified in the instructions for *Wall Drawing #716* (see image caption above left). Explore documentation and video of a sample project at http://www.andover.edu/Museums/Addison/AboutUs/AddisonUpdates/Pages/20141231_LewittMath.aspx.

I *Reconstruction of the Temple of Jerusalem*, from *Histoire d'Outremer,* by William of Tyre, 13th Century, **commons.wikimedia.org**

J Robert Frank (b.1924), *U.S. 285, New Mexico,* from series *The Americans*, neg. 1955-56, print c. 1981, gelatin silver print, 13 9/16 x 9 5/16 in., museum purchase, 1989.77.36

K Ralph Hamilton (1946-2006), *Study for "Eight Kindergarten Chairs, #2",* 1969, 17 1/2 x 22 1/2 in., graphite on graph paper, museum purchase, 1970.4

L Yvonne Pène du Bois (1913-1997), *The Wanamaker House, Washington Square, New York City,* 1938, oil on canvas, 29 3/4 x 48 in., gift of Alix W. Stanley, 1951.20

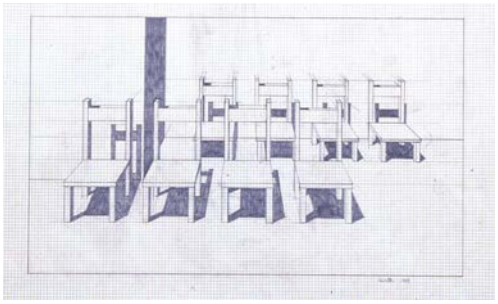
M Berenice Abbott (1898–1991), *Canyon, Broadway at Exchange Place*, from series *New York IV*, print 1979, gelatin silver print, 18 11/16 x 15 1/16 in., gift of Robert Feldman (PA 1954) in memory of Beth Lisa Feldman, 1980.20.10

N Walker Evans (1903-1975), *Untitled (skyscrapers, New York City)*, 1928-1930, gelatin silver print, 6 3/4 x 4 1/2 in., gift of Arnold H. Crane, 1985.46.67

O Josef Albers (1888-1976), *Structural Constellation*, 1953, incised bakelite, 17 1/8 x 22 5/8 in., gift of Mr. and Mrs. Charles H. Sawyer, 1991.161, © 2006 The Josef and Anni Albers Foundation/Artist Rights Society, New York

I

J



K

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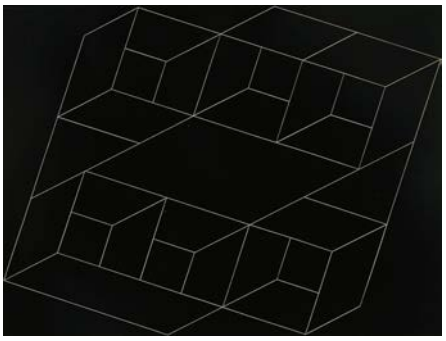


O

Perspective, Depth, and Similarity

How can math be used to understand spatial relationships between objects in perspective drawing?

How is three-dimensional space constructed on a two-dimensional plane?

Linear perspective is a mathematical system for creating the illusion of space and distance on a flat surface. The system of perspective we take for granted today originated in Florence, Italy in the early 1400s, demonstrated by artist and architect **Filippo Brunelleschi** and published by architect and writer **Leon Battista Alberti**. Artists drafted a receding grid on the floor or ground of their painting to act as a guide for the relative scale of all other elements within the picture. Alberti suggests relating the size of the floor squares to a viewer's height, a manifestation of the Renaissance shift from painting intended to glorify God–as it had been in Medieval Europe–to relating art to the viewer.

Contemporary systems also rely on math. If you look along a straight road, the parallel sides of the road appear to meet at a point in the distance, called the vanishing point (see image J). In one-point perspective, the objects face the viewer and drawing is guided by the geometry of lines converging at a single vanishing point (image K). When an object or viewpoint is rotated and two sides of an object are angled away from the viewer, each visible side of the object has its own unique lines of perspective. This creates two vanishing points, and is called two-point perspective (image L). If your viewpoint is higher or lower, such as looking up at a skyscraper (image M) or looking down from a high window (image N) a third vanishing point is used to create three-point perspective. Isometric shapes use parallel lines but no vanishing points, and are often used to convey technical information or to create artistic illusions (image O).

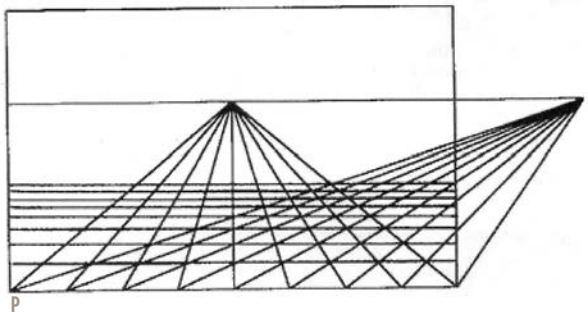
P Leon Battista Alberti, Perspective Diagram, 15th Century. **from en.wikipedia.org.**

Q-S from commons.wikimedia.org

Q One-Point Perspective Diagram

R Two-Point Perspective Diagram

S Three-Point Perspective Diagram

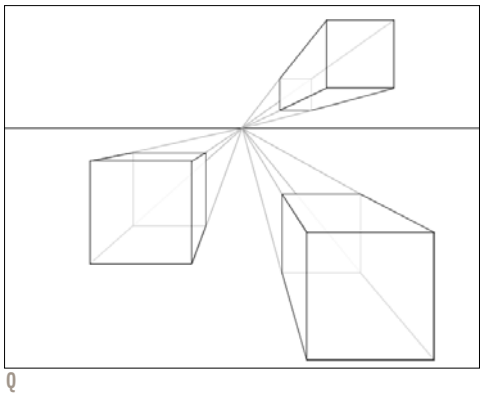


P

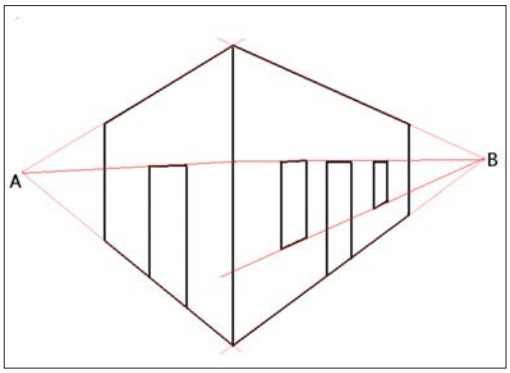
No one would deny that the painter has nothing to do with things that are not visible.

The painter is concerned solely with representing what can be seen.

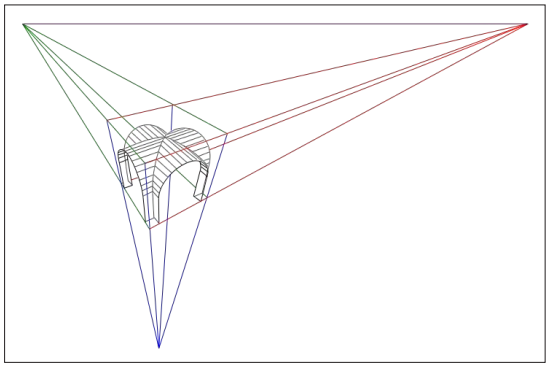
- Leon Battista Alberti, 1435 [1]



Q



R



S

Perspective, Depth, and Similarity

Connected Activities:

Explore Ratios and Similarity

1. Draw receding objects using a Pavimenti.
   - Construct a Pavimenti diagram. Instructions can be downloaded from: http://thewalters.org/assets/pdf/lesson-plans/perspective-on-pavimenti.pdf
   - Calculate the ratio between each row on your gridded "floor" and the rows above and below it.
   - How can this information help you to draw receding objects of the appropriate size?
2. Draw receding objects using one-, two-, and three-point perspective.
   - Draw a horizon line and place vanishing points.
   - Use your knowledge of geometry to construct objects within space.
3. Evaluation
   - Can you explain the mathematics that each process relies on?

See note 1 above: Alberti, Leon Battista. *On Painting*. [First appeared 1435-36] Translated with Introduction and Notes by John R. Spencer. New Haven: Yale University Press, 1970 [First printed 1956]. http://www.noteaccess.com/Texts/Alberti/

T INSTALLATION: *Faces of the Addison: Portraits from the Permanent Collection*, April 22 - July 31, 1994, Addison Gallery of American Art

U INSTALLATION: *80@80*, October 15 - December 31, 2011, Addison Gallery of American Art

V INSTALLATION: *The Works: A Survey of the Permanent Collection*, November 7 - January 11, 1969, Addison Gallery of American Art

W INSTALLATION: *Inside, Outside, Upstairs, Downstairs: The Addison Anew*, September 7, 2010 - March 27, 2011, Addison Gallery of American Art

Contact jkaplowitz@andover.edu for JPEGs of gallery installations.

T

U

V

W

Connected Activities:

Use provided data and collect additional data in the galleries (the average number of artworks in an exhibition, the approximate size of the walls, the average size of artwork on view, etc.) and calculate, chart, graph, scale, or interpret:

Combinations/Permutations: How many different exhibitions are possible?

Rate of Change: How has the collection grown over time?

Analyzing the Collection by the Numbers

How can mathematical calculations, including combinations, permutations, rate of change, and more help us to understand a museum's collection?

Sequence is important to the curatorial narrative of an exhibition. How does this impact your calculations?

The Addison Gallery of American Art opened to the public in 1931 with a collection of 400 objects. As of July, 2014, the museum's collection held 17,438 objects, spanning the 18th century to the present. The first photograph entered the collection in 1934. By 1974, the photography collection numbered 592, and today the total collection includes approximately 8,496 photographs. Among the Addison's holdings there are serial works, consisting of multiple components. The smallest such group consists of two or three objects, such as the triptych photograph of the Hoover Dam by contemporary photographer **Mark Klett**, while the largest is of 781 albumen prints by 19th century photographer **Eadweard Muybridge**.

The museum presents three exhibition seasons per year, each season consisting of between two and five unique exhibitions. These include both exhibitions from the permanent collection and exhibitions comprised of works on loan from other institutions.

X INSTALLATION: *Artist's Project: Tristan Perich*, September 7, 2010 - March 27, 2011

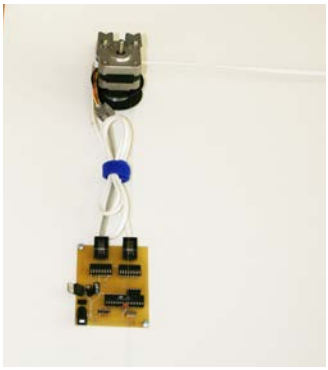
Y INSTALLATION DETAIL: *Artist's Project: Tristan Perich,* machine drawing computer chips, cord, motor, and string, 2010, Addison Gallery of American Art

Z Tristan Perich (b.1982), *2008-07-01, 7:04 PM to 11:54 PM*, 2008, ink on paper , 16 1/2 x 19 1/2 in., purchased as the gift of the Phillips Academy Parents Association and museum purchase, 2011.30

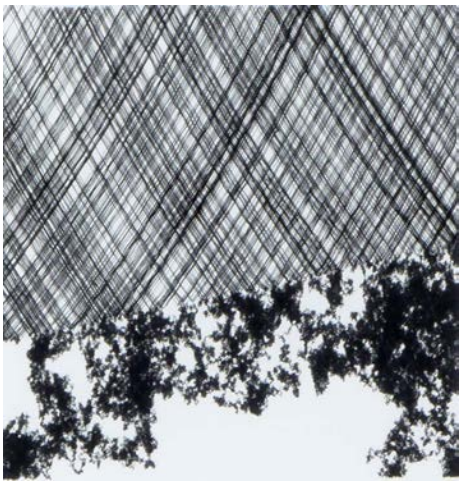
AA INSTALLATION DETAIL: *Artist's Project: Tristan Perich*, machine drawing clips, string, and marker, 2010, Addison Gallery of American Art

BB Tristan Perich (b.1982), *1-Bit Symphony,* 2010, electronic circuit, CD jewel case, silkscreen print of source code and schematic

X

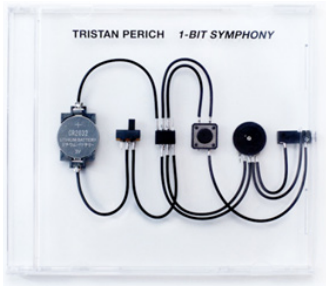


Y



Z

AA



BB

Systems, Order, and Randomness

How are art and music inspired by the aesthetic simplicity of math, physics, and code?

How can art find a balance between order and randomness, control and uncertainty?

Inspired by the aesthetics of math and physics, Phillips Academy alumnus **Tristan Perich** (PA '00) works with simple forms and complex systems. As a visual artist he works primarily with handmade machines to create delicately executed pen-on-paper or marker-on-wall drawings that explore the limits of traditional drawing through randomness and order. Like the work of Sol LeWitt (see page 3), Perich's work depends on the interaction between planning and the unpredictability of outcome. Perich writes, "While the motors' movements are the result of code executed precisely by machine, the final drawings come from the motion of pen on surface, and are wedded to effects from the physical world: the ripple of the string connecting pen to motor, the gradual depletion of ink, the texture of the paper. It is this balance between code and physics that excites me most, since the drawings couldn't be made without the code, and code needs to be realized in the physical world in order to be more than a set of instructions."[2]

In 2004 he began work on 1-Bit Music to experiment with the foundations of electronic sound, culminating in a physical "album," a music-generating circuit packaged inside a standard CD jewel case. His circuit album, *1-Bit Symphony*, is a long-form electronic composition in five movements. Its music explores the intricate, polyphonic potential of 1-bit audio, uniting simple with complex.

See note 2 above: http://www.tristanperich.com/#Artwork/Machine_Drawings

Arranging a Visit to the Museum Learning Center

At least two weeks in advance or preferably more, contact:

Jamie Gibbons
(978) 749-4037
jgibbons@andover.edu

to schedule your visit and discuss possible themes, applicable portfolios of works, and related activities.

Curriculum Connections and Resources

SUGGESTED CLASSROOM CONNECTIONS

Math

- ratios
- scaling
- similarity
- combinations and permutations
- area and perimeter
- computer science
- coding
- order and randomness
- systems
- rate of change
- functions
- probability
- statistics
- transformation and symmetry
- isometric shapes
- angles
- line and arcs
- polygons

History/Social Studies

- Renaissance, culture, and art
- Minimalism and the 1960s

Science

- color theory
- collecting and analyzing data

English

- pattern, rhythm, and rhyme
- symmetry
- mood, tone, and color
- perspective and point of view

Art

- abstract art
- conceptual art
- minimialism
- geometry in art
- perspective
- symmetry
- curating

CONNECTIONS TO ADDITIONAL THEMATIC PORTFOLIO GUIDES

Visualizing Science
Documentation vs. Art

TEACHER AND STUDENT RESOURCES

Perspective:

Bellanca, Kandra Wynne. *Perspective on Pavimenti: Finding Perspective Mathematically*. The Walters Art Museum/Young Audiences of Maryland Teacher Workshop 2007.
http://thewalters.org/assets/pdf/lesson-plans/perspective-on-pavimenti.pdf

Khan Academy. *How one-point linear perspective works.*
https://www.khanacademy.org/humanities/renaissance-reformation/early-renaissance1/beginners-renaissance-florence/v/how-one-point-linear-perspective-works

Minguzzi, Silvia. *Another Perspectve: Optical Illusion and Visual Ambiguities in Contemporary Art.* Department of Art and Art History, Digital Design, Colorado State University, Graduate Art History Seminar, Spring 2013. http://www.silviaminguzzi.com/anotherperspective/linear.htm

Artists:

Frank Stella. http://www.moma.org/collection/artist.php?artist_id=5640
Josef Albers. http://albersfoundation.org/
Sol LeWitt. http://www.massmoca.org/lewitt/
Tristan Perich. http://www.tristanperich.com/

ADDISON
Addison Gallery of American Art

Addison Gallery of American Art
Phillips Academy, Andover, MA
Education Department

Jamie Gibbons
Head of Education

Christine Jee
Manager of School and Community Collaborations

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