GEORGIA INSTITUTE OF TECHNOLOGY

CIVIL & ENVIRONMENTAL ENGINEERING

CEE 8823 SPECIAL TOPICS: ARTS & GEOMETRY

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and

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COURSE DESCRIPTION

We will introduce students to the geometry of space and manifolds and how these concepts influenced modern arts and sciences, i.e. Cubism and Einstein's relativity. The realization of geometry is visualization. The course is integrated with weekly lab sessions taught by the Atlanta-based professional artist Rachel Grant, who will teach students fundamentals of several art mediums: pencil and charcoal drawing, oil painting, photography, three-dimensional (3D) sculptures and brainwave art using EEG technology. In particular, students will draw/sketch by hand in order to stimulate/enhance their visual memory, imagination and practice abstraction of geometric concepts. Special focus is put on both exact representation (Renaissance art) and geometric abstraction (cubism, modern Art). Students' artwork will be exhibited in the Georgia Tech Ferst Center of the Arts.

WHY SHOULD YOU TAKE THIS COURSE?

Albert Einstein and Pablo Picasso, icons of the twentieth century have inspired generations of artists and scientists. Modern science is Einstein and modern art, Picasso. Albert Einstein's 1905 seminal paper on special relativity marks the beginning of modern sciences shaking the foundations of Newtonian physics. In 1907 Picasso had produced "Les Demoiselles d'Avignon" the painting that brought art into the twentieth century and initiated the cubism movement. At the core of these rebellious changes was the debate about representation versus abstraction. In art, realism, perfection, figuration have dominated since the Renaissance. The twentieth century marked the emergence of a strong countermovement represented by the postimpressionism of Paul Cézanne. In Science, mathematicians started to explore exotic non-Euclidian geometries in dimensions greater than three, especially four-dimensional spaces, with its implication of motion in space or time. Furthermore, there was the discovery of the conceptual quality of African art that influenced Picasso and other artists enormously. All of these ideas helped Picasso to free himself from earlier constraints of thinking, perfection and exact perspectives. He undertook the intellectual quest of reducing forms to geometry, leading to cubism. Picasso's exploration of space in his groundbreaking Les Demoiselles d'Avignon employed notions of four-dimensional space, non-Euclidean geometry, spacetime simultaneity and the fourth dimension. Picasso discovered geometry as the language of the new art thanks to Poincaré's insights on time and simultaneity. These were also inspirational to Einstein's discovery of relativity. Both Picasso and Einstein realized that we couldn't trust our senses when thinking about space and time. As a result, art and science become means for exploring the world surrounding us beyond perceptions, beyond appearances. Picasso believed that direct viewing, exact perspective and realism of the Renaissance art are deceiving and his cubism proposes a new notion of aesthetics. Picasso's new aesthetic for the Demoiselles was the reduction of forms to geometry. Einstein's approach to space and time was not primarily mathematical. To Einstein, the Maxell equations missed an aesthetic symmetry, which was essential to his discovery of relativity.

LEARNING OBJECTIVES

- Enhance engineering drawing skills by acquiring fluidity in drawing to attain fluidity in thinking: aim at freeing students' minds from mechanistic concepts and recipes when they approach the solution of a problem towards an abstraction to the essential elements and forms of the solution.

- Enhance students' observational skills by drawing from life like Leonardo da Vinci and Vincent van Gogh did. Enhance students' engineering drawing skills to capture the essential elements of nature using gestures and geometry.

- Learn notions of differential geometry to understand non-Euclidean geometries and how these concepts influenced the breakthrough in Modern Sciences and Arts: Einstein's relativity and Picasso's cubism.

- Acquire a general understanding of wave phenomena from a geometric perspective, in particular Einstein's gravitational waves.

- Revisit rigid-body mechanics from a geometric perspective and learn how to apply Lagrangian and Hamiltonian formalism to solve for the Newtonian dynamics.

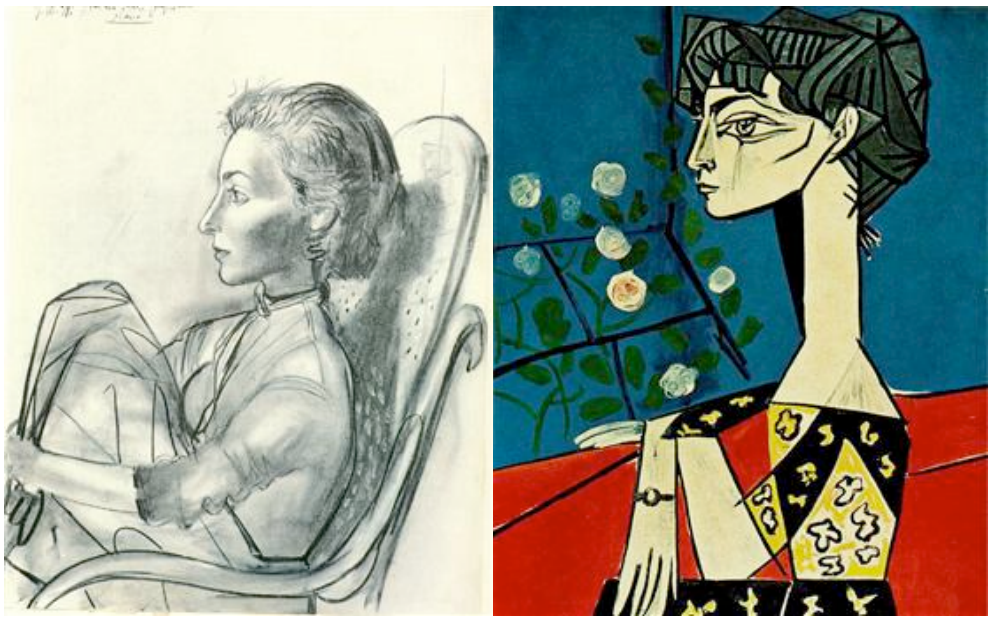

Figure 1: Picasso drawing (left) and painting (right)

PAST ART EXHIBITS

- Dec 11, 2018 "Like Picasso & Einstein: lines, forms and dimensions" at *Kai Lin Art Gallery*, Atlanta

  CEE News: https://ce.gatech.edu/news/art-and-geometry-exhibition-features-student-art-inspired-einstein-and-picasso

  YOUTUBE video: https://www.youtube.com/watch?v=c0WjBoWJQKo

- Dec 11, 2019 "Form and Expression: Artistic Lines from Analytical" at *Georgia Tech School of Civil & Environmental Engineering, Mason Building*Atlanta

  YOUTUBE video: https://www.youtube.com/watch?v=lmRfgl5EORc

- Dec 14, 2021 "Expressions of Analytical Minds" at *Georgia Tech School of Civil & Environmental Engineering, Mason Building* Atlanta

  YOUTUBE video: https://www.youtube.com/watch?v=zhVlnawkDCw

COURSE MATERIALS

- Fedele's class notes.
- Arthur J. Miller 2001 Einstein, Picasso, Space, Time, and the Beauty That Causes Havoc. Perseus Books Group
- The Geometry of Physics: An Introduction 3rd Edition by Theodore Frankel
- Elie Cartan, Lessons on Integral Invariants
- Ruthford Aris Vectors, Tensors and the Basic Equations of Fluid Mechanics
- Walt Reed The Figure: The Classic Approach to Drawing & Construction https://www.amazon.com/Figure-Classic-Approach-Drawing-Construction/dp/0891340971

GRADING

Homework	**30%**
Art Studio assignments	**30%**
Final Project	**40%**

NOTE ON ART STUDIOS, HOMEWORK AND FINAL PROJECT

- Weekly art labs will be taught by artist Rachel Evans Grant, who will teach the fundamentals of several art mediums: pencil and charcoal drawing, oil painting, photography, three-dimensional (3D) sculptures and brainwave art using EEG technology.

- There will be two kind of homework. Art homework will be assigned to assess students' comprehension of Art history and to learn about the life and artwork of famous artists and masters. Geometry homework will be assigned to assess students' comprehension of geometrical concepts to describe manifolds and their applications to solid body mechanics and relativity.

- Art studio assignments consist on the execution of 3d (wire) sculptures, photography, brain arts, oil paintings and drawings of various kinds (still life objects, perspectives, figure drawing portraits, etc.) using graphite, charcoal or ink in order to apply the fundamentals taught by the artist Rachel Evans Grant.

- The final project consists on the execution of a still life drawing, oil painting self-portrait, 3d sculptures, and photography as well as brain arts. At the end of the semester, students' artwork will be then exhibited in the Mason building.

COURSE GRADING SCALE

$90 < A \leq 100$

$80 < B \leq 90$

$70 < C \leq 80$

$60 < D \leq 70$

$F \leq 60$

COURSE POLICY

- Plagiarizing is defined by Webster's Dictionary as "to steal and pass off (the ideas or words of another) as one's own: use (another's production) without crediting the source." If caught plagiarizing, you will be dealt with according to the GT Academic Honor Code.
- Cheating off of another person's test is unethical and unacceptable. Cheating off of anyone else's work is a direct violation of the GT Academic Honor Code, and will be dealt with accordingly.
- For any questions involving these or any other Academic Honor Code issues, please consult the instructor or www.honor.gatech.edu.
- Homework and Art studio Lab assignments: I expect to receive your submissions posted in Canvas by the due time. A **zero grade** is assigned to a late submission.
- You may work with other classmates to solve/prepare homework and lab assignments. However, you must turn in separate versions with the following written on it: your name and the names of everyone you collaborated with.
- Unauthorized use of any previous semester course materials, such as tests, quizzes, homework, projects, and any other coursework, other than that provided by the instructor, is prohibited in this course. Using these materials will be considered a direct violation of academic policy and will be dealt with according to the GT Academic Honor Code. For any questions involving these or any other Academic Honor Code issues, please consult the instructor or www.honor.gatech.edu.
- **Office Hours**: to meet students' requirements, needs, and comfort levels, meetings and office hours will be offered in-person, virtually, or outdoors.
- Students are expected to be familiar with and abide by the Institute guidelines, information, and updates related to Covid-19. Find campus operational updates, Frequently Asked Questions, and details on campus surveillance testing and vaccine appointments on the Tech Moving Forward site.
- **Recordings of Class Sessions and Required Permissions:** classes may not be recorded by students without the express consent of the instructor unless it is pursuant to an accommodation granted by the Office of Disability services. Class recordings, lectures, presentations, and other materials posted on Canvas or Piazza are for the sole purpose of educating the students currently enrolled in the course. Students may not record or share the materials or recordings, including screen capturing or automated bots, unless the instructor gives permission.

OFFICE OF DISABILITY SERVICES

The Georgia Institute of Technology has policies regarding disability accommodation, which are administered through The Office of Disability Services (http://disabilityservices.gatech.edu/). For students with disabilities, please contact this Office to request classroom accommodations.

COMMUNICATION PROTOCOL

- All questions regarding lectures/homework will be addressed through the venue of PIAZZA (www.piazza.com).
- I will ONLY reply to emails concerning topics/issues that cannot be addressed via PIAZZA.
- Students are strongly encouraged to participate to discussions in PIAZZA so they can learn from their peer colleagues.
- SUBJECT line in email: SUBJECT: CEE8823- Meaningful Tag Line. Family name

Figure 2: Picasso paintings

COURSE TOPICS

HISTORY OF THE ARTS

Week 1: From the Renaissance to the Modern Art period.
Weeks 2: Studying the Masters of Arts: Giotto, Botticelli, Leonardo da Vinci, Raffaello, Michelangelo, Rubens, Bernini, Caravaggio, Titian, Giorgione
Weeks 3: Studying the Masters of Arts: Vincent Van Gogh, August Renoir, Claude Monet, Eduard Manet, Berthe Morisot, Paul Cezanne, Pablo Picasso, George Braque, Amedeo Modigliani, Henri Matisse, Marc Chagall, Andre' Lhote, Tamara de Lempicka, Edward Hopper, Wassily Kandinsky, Piet Mondrian, Giorgio de Chirico, Mark Rothko, Jackson Pollock
Week 4: Einstein versus Picasso. Picasso artwork: blue period, rose period, African period, Analytical and synthetic Cubism period, late years; Influence of geometric and esthetics concepts on both sciences and arts. Poincaré's insights on time and simultaneity and their influence on the discovery of Einstein's relativity and Picasso's cubism.

GEOMETRY

Week 5: Vector spaces, scalar and wedge products, covariant and contravariant vectors, dual spaces
Week 6: Dual spaces, covectors, Cartan's differential forms, variational calculus.
Week 7: Geometry of manifolds: intrinsic formulation, the concepts of chart and atlas, Tangent and

Cotangent spaces, tangent and cotangent bundles, concept of metric
Week 8: Covariant derivative, fiber bundles, geometric connections, parallel transport, geodesics, geodesic equations
Week 9: geodesic deviations, Riemannian curvature tensor, Ricci tensor, Bianchi's identity.

APPLICATIONS
Week 10-11: Geometric approach of rigid-body mechanics; Lagrangian and Hamiltonian of a free particle and rigid bodies, holonomic and non-holonomic constraints.
Week 12: Special relativity, time and space are relative
Week 13-14: General relativity and Einstein's equations
Week 15: Wave phenomena: what is a wave? Definitions, Properties, Wave dispersion and physical examples, Einstein's gravitational waves

ART STUDIO LABS

Week 1: Intro to the artist/instructor, introductory research testing, intro to art supplies, Exercise #1, positive and negative space mug drawings.
Week 2: Contour drawing, evaluating line weight, charcoal gradient scales and drawing one-point and two-point perspective. Begin Assignment #1, Shoe Drawing with charcoal.
Week 3: Drawing with graphite using hatching, cross hatching, stippling, shading.
Continue Assignment #1, Shoe Drawing with charcoal.
Week 4: Sphere drawing. Finish Assignment #1, Shoe Drawing with charcoal. Introduce next project, have students bring in everyday object to render in 3d.
Week 5: Introduction to critique, critique shoe drawings. Introduction to 3-d art/sculpture. Start Assignment #2, Wire Sculptures of everyday objects.
Week 6: Assignment #2, Wire Sculptures of everyday objects.
Week 7: Fundamentals of composition and intro to color theory. Begin Assignment #3, photography. Introduction to oil painting supplies, basic paint palette, brushes, mediums. Exercise #1, Color Wheel.
Week 8: Oil painting brush techniques. Begin Assignment #4, plein air painting.
Week 9: Critique photographs. Assignment #4, plein air painting.
Week 10: Principles of figure drawing: human forms, proportions and structure. Drawing facial and proportions. Assignment #5, Self- portraiture.
Week 11: Assignment #5, Self- portraiture.
Week 12: Introduction to brain art using EEG technology. Finish Assignment #5, Self- portraiture.
Week 13: Assignment #6: Self- guided brain art
Week 14: Assignment #6: Self- guided brain art
Week 15: Final critique of self- portrait and final research testing. Finish Assignment #6: Self- guided brain- art
Final exhibition

ART SUPPLIES LIST

We will discuss supplies on the first day of class.
You are only responsible for bringing the indicated items to the first day of class

Art Supplies	Details	Links
Vine Charcoal*	medium or soft ***bring to first day of class**	https://www.dickblick.com/products/blick-studio-charcoal/
White eraser*	***bring to first day of class**	https://www.dickblick.com/products/prisma color-magic-rub-eraser/
Newsprint pad	18" x 24" ***bring to first day of class**	https://www.dickblick.com/products/blick-studio-newsprint-pads/?fromSearch=%2Fsearch%2F%3Fq%3D18%2522%2520x%252024%2522%2520newsprint%2520pad
One 5” x 7” notecard or piece or stiff paper*	Viewfinder [we will review making this in class] Cut 4" x 3" rectangle window from 5” x 7” notecard or stiff paper ***bring to first day of class**	
Ruler*	***bring to first day of class**	
Pack of 6 drawing pencils	8B, 6B, 4B, 2B, B, HB	https://www.dickblick.com/items/staedtler-lumograph-pencil-set-of-6/
Graphite stick		https://www.dickblick.com/products/generals-wide-compressed-graphite-sticks/
Pencil sharpener		
Kneaded eraser		https://www.dickblick.com/items/generals-kneaded-eraser-large/
Gray paper stump/blender		https://www.dickblick.com/items/pro-art-blending-stumps-medium-pack-of-3/
Compressed Charcoal		https://www.dickblick.com/items/alphacolor-charcoal-black--pack-of-3/
White charcoal/conte		https://www.dickblick.com/items/generals-white-charcoal-pack-of-4/

Charcoal pencil		https://www.dickblick.com/items/generals-charcoal-pencil-kit/
Strathmore 400 Series Drawing Paper Pad	18" x 24"	https://www.dickblick.com/items/strathmore-400-series-drawing-paper-pad-18-x-24-24-sheets/
Sketchbook	Unlined paper	
Spray Fixative [or hairspray]		
Set of water mixable oil paints	Specific colors TBA	
2 plastic cups	Can be disposable, for paint water	
Roll of paper towels		
Bristle paint brushes, synthetic or natural	One large flat brush, 1 inch wide One medium filbert brush One small/medium bright brush One small round brush *Ensure that they are for oil painting, the store display will be labeled* *Look for paint brushes with a long handle*	Amazon
Canvas	(2) 9” x 12”, (2) 11” x 14”, (1) 16” x 20”	
Palette knife	Pointed/trowel shaped	
Palette paper pad		
Dishwashing soap for cleaning brushes		
Optional:		
Portfolio [to hold drawings]	19” x 26”	
Clip drawing board	23” x 26”	
Painters tape 1”		
Suggested Retailers:		
Blick	https://www.dickblick.com/	878 Peachtree St NE, Atlanta, GA 30309
Sam Flax	https://www.samflax.com/	1495 Northside Drive NW Suites B and C, Atlanta, GA 30318