ARCH 5304- 301: Advanced Architectural Representation

College of Architecture, Texas Tech University

Fall 2021

Meeting Time, Days, and Location: 10:30 AM- 11:50PM, MW, Architecture 00102

Instructor: Assistant Professor Erin Linsey Hunt, erin.hunt@ttu.edu

Figure 1, at left 3D printed PLA joints for 1/8" diameter wire a simliar assignment will be given as assignment 01. At right, is a Rockite cast created using 3D printed PLA formwork. This student work was completed at Iowa State University. A similer assignment will be given for assignment 02.

Course Title Introduction to Computational Design and Fabrication

Catalog Description: Explores and examines emerging methods of computation as generative tools of the design process, in which design intent is captured through algorithmic processes and parametric ideas.

Course Description
This course will introduce students to computational design and digital fabrication. It will teach students how to understand and compose Grasshopper definitions and introduce students to digital fabrication through hands-on assignments. The scale and complexity of these assignments increase throughout the semester as the skills are acquired. The emphasis is to take risks and learn with each iteration to allow students to experiment and test new computational design skills, materials, and fabrication methods without the fear of failure and constraints of a studio model. The students are asked to develop a research question with each assignment then document their progress. For the final project, the students will revisit a past assignment and conduct another iteration with additional knowledge accumulated over the semester.

Student Learning Objectives
Upon the completion of this course, the student will be able to:

- Comprehend advanced topics in complex geometry generation and manipulation.
- Understand and compose their own Grasshopper definitions.
- Leverage computational workflows to digitally work more efficiently and effectively.
- Understand the fundamentals of computation and digital fabrication and how the two are related and complement one another.
- Translate abstract geometrical information to machine instructions that can be executed by digital fabrication tools such as 3D printers, laser cutters, and CNC routers.
- Use data to inform their design decisions.

- Properly create a research question and investigate it through iterative experimentation and written reflection.

Student Performance Objectives
Upon completion of this course, the student will be able to:

- Understand the basic logic and strategies of computational design.
- Have an intermediate knowledge of McNeel's Grasshopper.
- Understand the basic history and workflows of digital fabrication tools.
- Understand how to ask and investigate a research question.

Means of Evaluation:
Evaluations for this course will be based on the work that you produce. There will be no quizzes or examinations. There will be four means for evaluation:

- *Workouts*: these allow for material from the lectures to be applied via exercises meant to strengthen your understanding of the course's key concepts. These are meant to be completed independently. If you are struggling, please let your instructor know so that they can assist.
- *Assignments*: a few assignments will be given. These are meant to apply your computational knowledge to fabrication questions. The entire assignment may not be computationally based, but each assignment will have a certain component that will require the composition of a Grasshopper definition. The definitions will be related to concepts that are taught in the course. These assignments allow for some experimentation with digital fabrication methods such as 3D printing, laser cutting, and CNC routing. These assignments will be centered around a research question and will be completed in small groups.
- *Final Project*: This project will expand upon one of the assignments completed during the course. The groups working on these projects can be the same or different. The goal is to take the knowledge accumulated throughout the course and create a new iteration of this work.
- *Final Portfolio*: Each student will submit a final, packaged InDesign folder with all their work from this course, including documentation of their workouts, assignments, and the final project.

Depending on the course participants' interest, it could be fun to have a final exhibition or review with a jury of faculty to show off the work created in this course.

Computational design and fabrication take trial and error. Please do not wait until the last minute to complete work for this course. These workouts and assignments will better prepare you for your work in other classes and could potentially expedite your digital workflows and enhance your model-making skills.

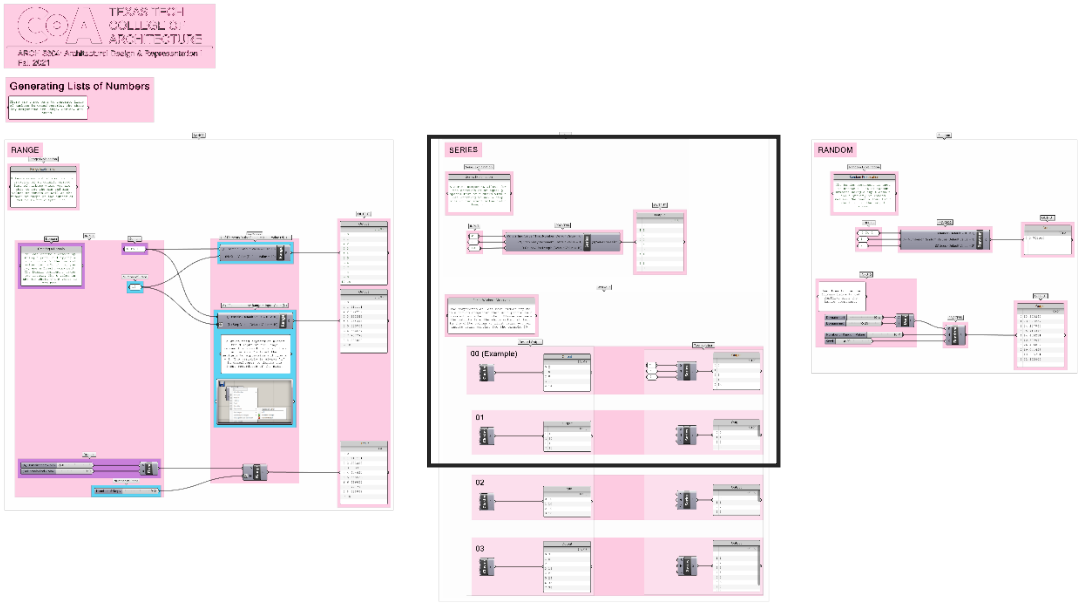

Figure 2, Workouts will mainly come in the form of Grasshopper definitions that further investigate concepts discussed in class with heavy notation to assist in understanding and learning. The above image is part of the list and list operations workout 02.

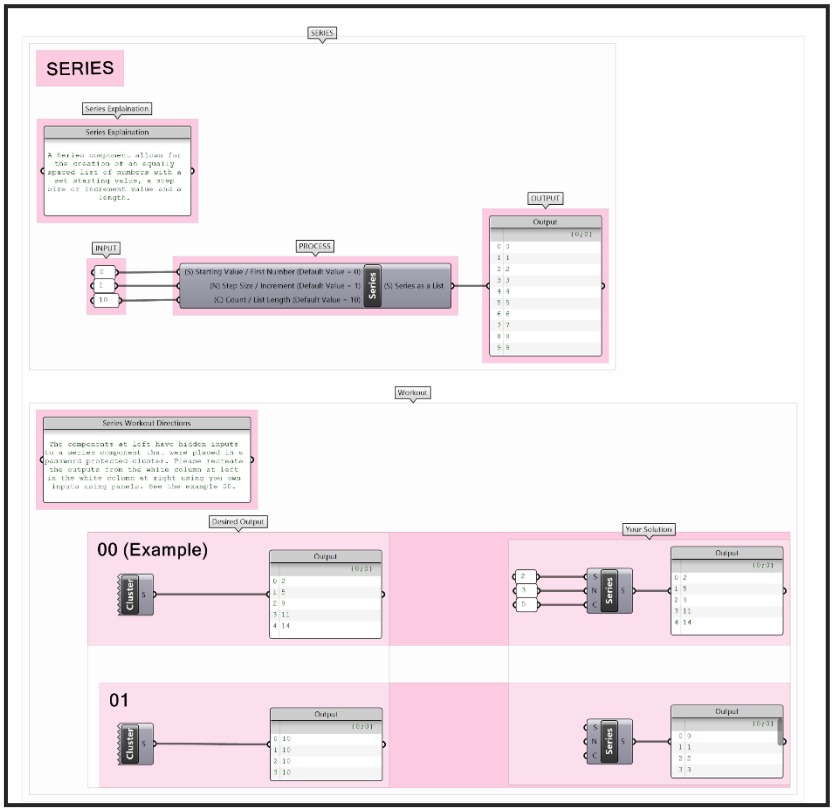

Figure 3, This image is the boxed call out from Figure 2, which shows the explanation of the component series. In this work, this component is introduced, the inputs and outputs are explained and heavily notated. The workout problems provide an example that denotes the inputs required to get the desired output. The student will need to figure out the proper inputs to get the desired output for the series components below the example to complete the workout.

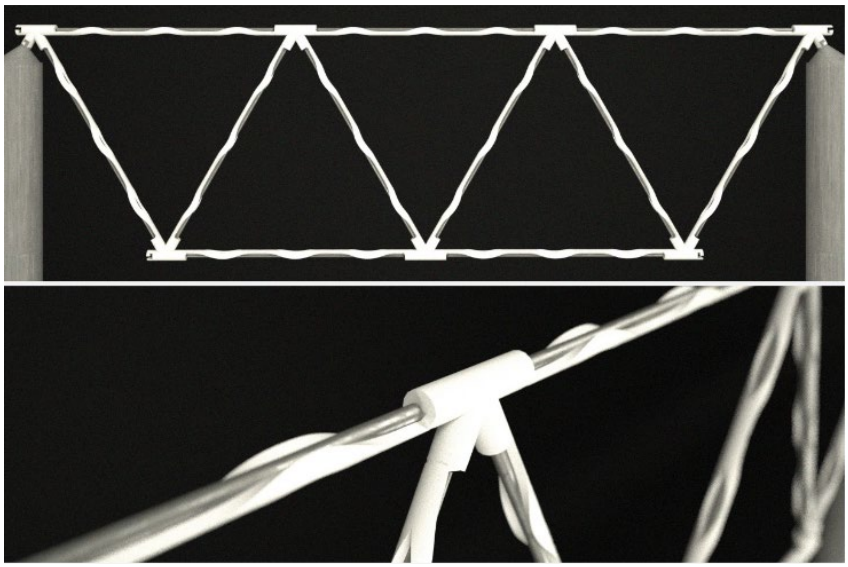

Figure 4 shows a wire truss held together with 3D printed joints. This assignment is meant to get students familiar with 3D printing and its tolerances. Students completed this project at Iowa State University in the fall of 2017. Assignment 01 could yield similar results.

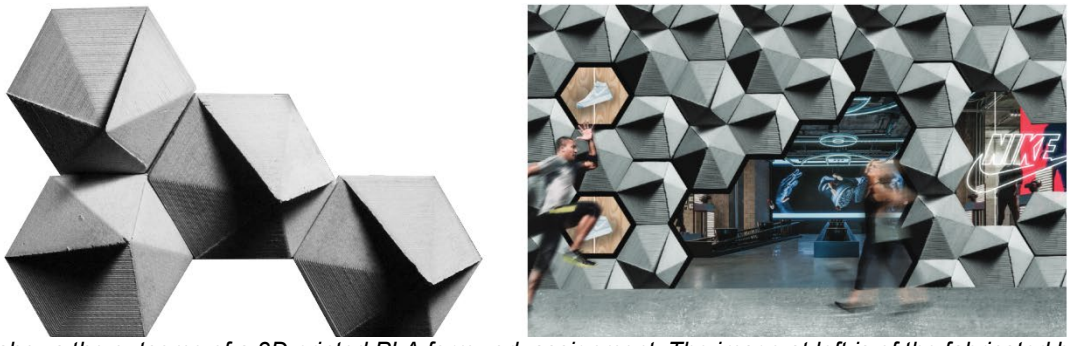

Figure 5 shows the outcome of a 3D printed PLA formwork assignment. The image at left is of the fabricated blocks. The render at right is of this block design implemented on a store façade. Students completed this project at Iowa State University in the fall of 2017. Assignment 02 could have similar final outputs.

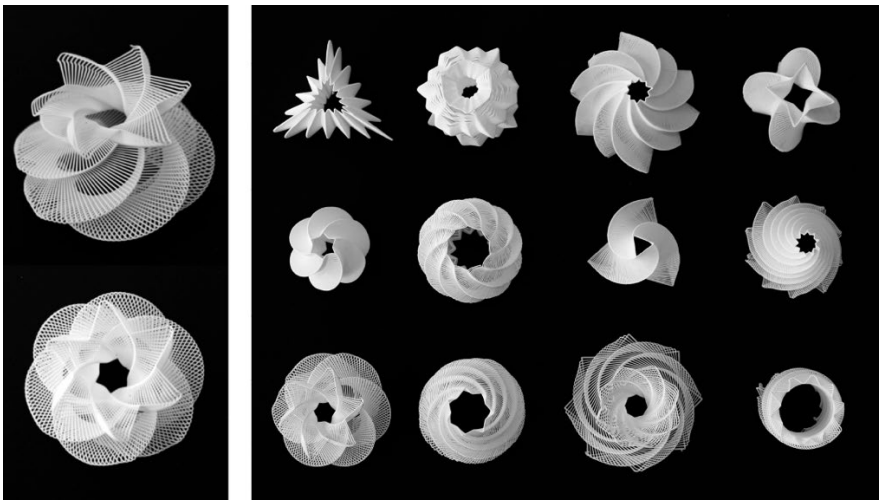

Figure 6 shows small PLA 3D prints using a single curve as a toolpath. This was work completed for an assignment at the Harvard Graduate School of Design by Katarina Richter-Lunn, Sana Shama, and myself. Potentially similar outcomes will result from Assignment 03.

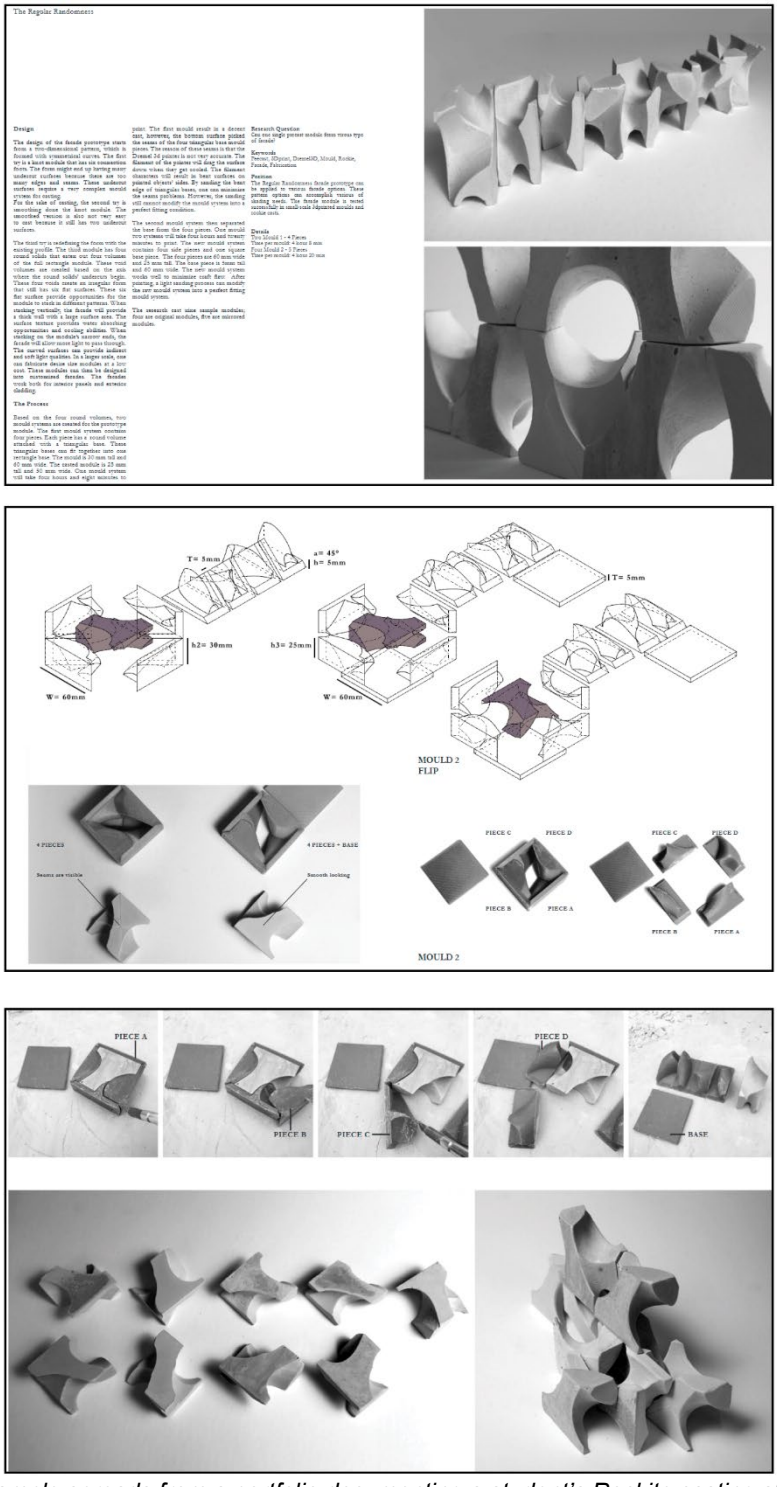

Figure 7 shows sample spreads from a portfolio documenting a student's Rockite casting study at Iowa State University in the fall of 2017. The project portfolios will include precedent studies, a research question, discussion of the various iterations and the results, orthographic and axonometric drawings, high-quality photographs, speculative renders, and the project's computational logic denoted through text and diagrams.

Teaching Methods:
This course will be lecture-based. Each week the faculty will introduce topics relating to McNeel's Grasshopper to the students. These topics will get more complex as the semester progresses. Workouts will complement the computational design lectures in the form of highly annotated Grasshopper definitions with logical problems to assist the student in comprehending these topics. Throughout the semester, digital fabrication will be introduced through a series of lectures discussing precedent projects, 3D printing, CNC routing, formwork creation and casting, toolpath generation, the basics of robotics. Many of these topics will have associated projects that allow small groups to attempt some of these fabrication techniques. They will be asked to find precedents, create a research question, document their design iterations, and reflect on their findings. This will allow the students to experience the research process. The faculty will assign additional reading throughout the semester from various sources listed in the Required Text section.

Course Schedule
******Dates are subject to change at the discretion of the instructor and/or the College of Architecture. ******

WK	DATE	AGENDA	HOMEWORK	TTU/CoA/5304
1	08/23/21	Course Introduction, Assign Precedent Assignment 00	Complete surveys, Download + Install Windows Rhino 7, Precedent Assignment 00 Assigned	
	08/25/21	Grasshopper Interface Basics + Communicating with Rhinoceros	Workout 00 Assigned	
2	08/30/21	Introduction to 3D Printing + Research	Assignment 01 Assigned	
	09/01/21	Points, Vectors, Planes and Mathematics, Expressions and Conditions	**Precedent Assignment 00 Due** Workout 01 Assigned	
3	09/06/21	**No Class**		**Labor Day Holiday!**
	09/08/21	Introduction to CNC Routing		
4	09/13/21	Lists, their Operation and Management	**Workout 01 Due** Workout 02 Assigned	
	09/15/21	Groups Present Assignment 01 to the Class	**Assignment 01 Due**	
5	09/20/21	Surface Geometries + Meshes	**Workout 02 Due** Assignment 02 Assigned	
	09/22/21	Introduction to Formwork and Casting	Workout 03 Assigned	
6	09/27/21	Data Trees	**Workout 03 Due**	
	09/29/21		Workout 04 Assigned	
7	10/04/21	Transformations	Workout 05 Assigned	
	10/06/21	Groups Present Assignment 02 to the Class	**Workout 04 Due** **Assignment 02 Due**	
8	10/11/21	Compound Transformations + Synthesizing What Has Been Learned	**Workout 05 Due** Assignment 03 Assigned	
	10/12/21		Workout 06 Assigned	
9	10/18/21	Creating Custom Toolpaths for Digital Fabrication		
	10/20/21		**Workout 06 Due**	
10	10/25/21	Plugins + Advanced topics in Grasshopper to be determined by student interest through a survey.	Final Project Assigned	
	10/27/21			
11	11/01/21			
	11/03/21	Groups Present Assignment 03 to the Class	**Assignment 03 Due**	

12	11/08/21	Introduction to Robotics		
	11/09/21			
13	11/15/21	Introduction to Basic Programming within Grasshopper + Desk Crits for Final Project		
	11/17/21			
14	11/22/21			
	11/24/21		No class!	Thanksgiving
15	11/29/21			
	12/01/21			**TTU Final Examinations**
16	12/06/21			**TTU Final Examinations**
	12/07/21			**TTU Final Examinations / Fall semester Ends**

Required Texts
A collection of readings will be made available on the course Blackboard. Students are expected to complete the required readings by the date specified in the workout or assignment.

Digital References
- Issa, Rajaa. **Essential Mathematics for Computational Design**. McNeel, 2010. *https://www.rhino3d.com/download/rhino/6/essentialmathematics*
- Issa, Rajaa. **Essential Algorithms and Data Structures**. McNeel, 2020. *https://www.rhino3d.com/download/rhino/6.0/essential-algorithms*
- **CumInCAD**, a cumulative index about publications in Computer Aided Architectural Design *http://papers.cumincad.org*

Computational Design References
- Woodbury, Robert Francis, et al. ***Elements of Parametric Design***. Routledge, 2010. (Available at the TTU Library)
- Ko, Joy, and Kyle Steinfeld. ***Geometric Computation: Foundations for Design***. Routledge, 2018.
- Reas, Casey, and Ben Fry. ***Processing: A Programming Handbook for Visual Designers and Artists***. The MIT Press, 2014.
- Bohnacker, Hartmut, et al. ***Generative Design: Visualize, Program, and Create with Processing***. Princeton Architectural Press, 2012.
- Reas, Casey. ***Form+Code in Design, Art, and Architecture***. Princeton Architectural Press, 2010.

Digital Fabrication References
- Lostritto, Carl. ***Computational Drawing from Foundational Exercises to Theories of Representation***. Applied Research & Design, 2019.
- Cuevas, Diego García, and Gianluca Pugliese. ***Advanced 3D Printing with Grasshopper®: Clay and FDM***. IndependentlyPublished, 2020.
- Johnston, Lucy. ***Digital HANDMADE: Craftsmanship in the New Industrial Revolution***. Thames & Hudson, 2017.
- Redwood, Ben, et al. ***The 3D Printing HANDBOOK: Technologies, Design and Applications***. 3D Hubs, 2018.
- Rael, Ronald, and Virginia San Fratello. ***Printing Architecture Innovative Recipes for 3d Printing***. Princeton Architectural Press, 2018.

Course Requirements
A computer and internet connectivity are required for this course. Students need to have and maintain a personal laptop computer to complete their studio assignments. Please see the college's website for more details regarding minimum specifications. With the ongoing COVID-19 pandemic, the laptop must have a working camera and microphone. Please be sure to back up your work to an external hard drive and the cloud regularly, at a minimum once per week, preferably daily. Technical difficulties, including but not limited to viruses, corrupted files, crashes, server, or print bureau problems, will not be accepted as excuses for not having work completed on time.

Required Software
Please use legal copies of these software since use of illegal versions violates ethical code and can cause unexpected results.

1. McNeel's Rhinoceros3D 7 (Educational License)
2. Adobe Creative Cloud or Suite specifically students must have access to Photoshop, Illustator, InDesign, Premiere Pro, After Effects, and Acrobat DC

Grading
Rubrics will be provided for each assignment that will include the rationale behind each grade.

Grades and their Interpretations
A: Excellent- Work of exceptional merit, exceeding the requirements of the course, showing strong understanding of skills, effort, initiative, and resourcefulness.
B: Good- Performance above the norm, work that demonstrates acceptable comprehension, skills, effort, initiative, and improvement beyond the minimum requirements of the course.
C: Average- Work meets the minimum requirements and demonstrates satisfactory understanding, skills, and effort but displays little initiative to investigate the problem without substantial push from the instructor, the work completed shows minimal improvement.
D: Inferior- Passing, but not necessarily satisfying the degree requirement. Work that does not meet the minimum requirements for understanding, skills, and effort. The student's initiative was lacking, and their improvement was not noticeable.
F: Failure- Does not meet the requirements to advance the student so the course must be repeated.

For more on grading visit: TTU OP. 34.12 https://www.depts.ttu.edu/opmanual/OP34.12.pdf

The seminar grade will consist of four parts:

Attendance + Participation in Class	10%
Workouts	20%
Assignments	30%
Final Project + Portfolio	40%

Retention of Work
I give the College of Architecture and Texas Tech University, and/or Texas Tech University System (herein, "Texas Tech") the absolute right and unrestricted permission to collect, use, publish, reproduce, edit, exhibit, project, display and/or copyright work created by me during the course of my education at Texas Tech, through any form (print, digital, physical model, broadcast or otherwise) at any campus or elsewhere, for art, advertising, future accreditation, visiting committees, recruitment, marketing, fund raising, publicity, archival or any other lawful purpose.

NAAB Criteria Met (use 2020 SPC's)
Program Criteria (PC)
PC.5 Research and Innovation-

"How the program prepares students to engage and participate in architectural research to test and evaluate innovations in the field."

Attendance Policy

1. Students are responsible for attending all scheduled class meetings for the full class period.
2. Attendance requires each student to have their computer, tools, materials, and supplies available for all studio activities.
3. When you are absent you miss important course content that effects student performance. You will have to work harder to make up for any absences.
4. Absences will affect the final grade at the instructor's discretion
5. Violating a maximum of four absences for studio will require the student to drop the class or receive a grade of "F" in compliance with drop deadlines (see COA Attendance policy).
6. Absences are only for reasonable unforeseen circumstances such as getting sick or emergencies. If you are sick, please stay home. Inform the instructor directly.
7. Any absence is considered UNEXCUSED, unless it meets the criteria discussed in the TTU Student Handbook, Part II Community Policies, Section D: Class Absences (page 62) for the following:
    a. Illness requiring an absence from class for more than one week.
    b. Religious Holy Day Absences.
    c. Student Absence due to Sponsorship of Student Activities and Off-Campus Trips.
    d. See section II on specific COVID-19 Instructions related to attendance.

II. COVID-19 INFORMATION

Face Covering Policy: As of May 19, 2021, face coverings are now optional in TTU facilities and classrooms, and all other COVID-19 campus protocols have been lifted. It is highly recommended that those who have not been vaccinated for COVID-19 wear face coverings to help prevent the spread of the virus.

Seating Charts and Social Distancing: There is no longer a mandated social distancing protocol for classroom seating, but diligence is encouraged when indoors and not wearing masks. A seating chart might be used in the classroom to facilitate attendance, class interactions and other in-class engagement activities.

Illness-Based Absence Policy:
[Instructors of Record may revert to their pre-pandemic absence policies regarding illnesses but take into consideration the variant effects of COVID-19 on people when students report absence due to the virus (e.g., some may need extended days of absences and time to make up missed work).]

In-Person Office Hours: [IoRs may provide their own statement here with provision that masks are optional but social distancing may be expected.]

Personal Hygiene: We all should continue to practice frequent hand washing, use hand sanitizers after touching high-touch points (e.g., door handles, shared keyboards,

etc.), and cover faces when coughing or sneezing.

Potential Changes: The University will follow CDC, State, and TTU System guidelines in continuing to manage the campus implications of COVID-19. Any changes affecting class policies or delivery modality will be in accordance with those guidelines and announced as soon as possible.

III. University Required Statements

ADA STATEMENT:
Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services during the instructor's office hours. Please note: instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For additional information, please contact Student Disability Services in West Hall or call 806-742-2405.

ACADEMIC INTEGRITY STATEMENT:
Academic integrity is taking responsibility for one's own class and/or course work, being individually accountable, and demonstrating intellectual honesty and ethical behavior. Academic integrity is a personal choice to abide by the standards of intellectual honesty and responsibility. Because education is a shared effort to achieve learning through the exchange of ideas, students, faculty, and staff have the collective responsibility to build mutual trust and respect. Ethical behavior and independent thought are essential for the highest level of academic achievement, which then must be measured. Academic achievement includes scholarship, teaching, and learning, all of which are shared endeavors. Grades are a device used to quantify the successful accumulation of knowledge through learning. Adhering to the standards of academic integrity ensures grades are earned honestly. Academic integrity is the foundation upon which students, faculty, and staff build their educational and professional careers. [Texas Tech University ("University") Quality Enhancement Plan, Academic Integrity Task Force, 2010]

RELIGIOUS HOLY DAY STATEMENT:
"Religious holy day" means a holy day observed by a religion whose places of worship are exempt from property taxation under Texas Tax Code § 11.20. A student who intends to observe a religious holy day should make that intention known in writing to the instructor prior to the absence. A student who is absent from classes for the observance of a religious holy day shall be allowed to take an examination or complete an assignment scheduled for that day within a reasonable time after the absence. A student who is excused under section 2 may not be penalized for the absence; however, the instructor may respond appropriately if the student fails to complete the assignment satisfactorily.

DISCRIMINATION, HARASSMENT, AND SEXUAL VIOLENCE STATEMENT:
Texas Tech University is committed to providing and strengthening an educational, working, and living environment where students, faculty, staff, and visitors are free from gender and/or sex discrimination of any kind. Sexual assault, discrimination, harassment, and other Title IX violations are not tolerated by the University. Report any incidents to the Office for Student Rights & Resolution, (806)-742-SAFE (7233) or file a report online at titleix.ttu.edu/students. Faculty and staff members at TTU are committed to connecting you to resources on campus.

Some of these available resources are: TTU Student Counseling Center, 806- 742-3674, https://www.depts.ttu.edu/scc/(Provides confidential support on campus.) TTU 24-hour Crisis Helpline, 806-742-5555, (Assists students who are experiencing a mental health or interpersonal violence crisis. If you call the helpline, you will speak with a mental health counselor.) Voice of Hope Lubbock Rape Crisis Center, 806-763-7273, voiceofhopelubbock.org (24-hour hotline that provides support for survivors of sexual violence.) The Risk, Intervention, Safety and Education (RISE) Office, 806-742-2110, https://www.depts.ttu.edu/rise/ (Provides a range of resources and support options focused on prevention education and student wellness.) Texas Tech Police Department, 806-742-3931,http://www.depts.ttu.edu/ttpd/ (To report criminal activity that occurs on or near Texas Tech campus.)

CIVILITY IN THE CLASSROOM STATEMENT:
Texas Tech University is a community of faculty, students, and staff that enjoys an expectation of cooperation, professionalism, and civility during the conduct of all forms of university business, including the conduct of student–student and student–faculty interactions in and out of the classroom. Further, the classroom is a setting in which an exchange of ideas and creative thinking should be encouraged and where intellectual growth and development are fostered. Students who disrupt this classroom mission by rude, sarcastic, threatening, abusive or obscene language and/or behavior will be subject to appropriate sanctions according to university policy. Likewise, faculty members are expected to maintain the highest standards of professionalism in all interactions with all constituents of the university (www.depts.ttu.edu/ethics/matadorchallenge/ethicalprinciples.php).

LGBTQIA SUPPORT STATEMENT*:
I identify as an ally to the lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) community, and I am available to listen and support you in an affirming manner. I can assist in connecting you with resources on campus to address problems you may face pertaining to sexual orientation and/or gender identity that could interfere with your success at Texas Tech. Please note that additional resources are available through the Office of LGBTQIA within the Center for Campus Life, Student Union Building Room 201, www.lgbtqia.ttu.edu, 806.742.5433."

Office of LGBTQIA, Student Union Building Room 201, www.lgbtqia.ttu.edu, 806.742.5433
Within the Center for Campus Life, the Office serves the Texas Tech community through facilitation and leadership of programming and advocacy efforts. This work is aimed at strengthening the lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) community and sustaining an inclusive campus that welcomes people of all sexual orientations, gender identities, and gender expressions.