ARCH 4.500/4.505 Design Through Computation and Making
3-0-9 U/G
Meets with
ARCH 4.105 Fundamental of Design and Fabrication
2-2-5 G

SCHEDULE
Tuesdays 9:00–12:00 am | Room W41-1402

Syllabus

INSTRUCTORS

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OVERVIEW

This class introduces concepts of parametric/computational design in architecture and integrates them with physical making exercises. The course will provide you with both the skills and foundational knowledge needed for using computational techniques in the design process. We will explore principles of designing forms using form-finding techniques informed by fabrication constraints. Relevant fabrication methods for construction will be examined through computational pipelines for production using available CNC tools (e.g., 3D printing, laser cutting, etc.).

The content will be taught through a combination of lectures, workshops, and lab sessions throughout the fall semester. These sessions will introduce you to the modelling software Rhinoceros3D coupled with visual programming plugins such as Grasshopper3D and, where appropriate, coding languages (e.g., Python). These skills will be directly applied in a final building design and manufacturing exercise/assignment carried out in groups of two students.

During the first part of the semester you will use lab time to familiarize yourself with the introduced software and computational design principles through a series of individual and group assignments. In the second part of the semester we will be learning the relationship between the digital and physical as a cycle of physical making and digital simulation. By cycling through physical prototyping, digital simulation, calibration, and fabrication, you will develop the integrated thinking that defines contemporary computational design practice.

LEARNING OBJECTIVES

Upon completing the class, you should be able to:

- Translate between the physical and digital domain:
  - extract design rules from built prototypes
  - validate computational models against physical reality
- Design parametrically:
  - Translate geometry into a parametric/computational model
  - Evaluate multiple solutions
  - Understand how fabrication limitations drive design decisions
- Analyse and improve non-standard geometries considering fabrication constraints
- Manufacture scaled structures using (available) digital fabrication methods (e.g. 3D printing and laser cutting)

Overview of weekly learning objectives

class	Learning Objectives
1	Geometric literacy; decompose architecture into primitives
2	3D modeling skills; translate observation to CAD
3	Computational thinking; algorithms from manual processes

4	Data structures; parametric control of geometry
5	Physics-based design
6	Rule extraction; topology as design driver
7	Form-finding principles; material behavior
8	Digital-physical calibration; form-finding simulation
9	Fabrication mastery; constraints as design drivers; group collaboration
10	Documentation; synthesis; professional communication
11	Integration; real-world making challenges; prototyping
Dec 8	final presentation skills (4.500)
Dec 15–18	Final presentation skills (4.105)

STRUCTURE

The course is divided into two parts:

Part I: Fundamentals
Part I will introduce you to modelling in Rhinoceros 3D, setting up parametric models in Grasshopper 3D and principles of fabrication using available machines. You will be introduced to principles of form-finding using Kangaroo and working with tensile structures both digitally and physically. A crucial component in this introduction will be establishing a relationship between digital design and the resulting physical prototype. In this part you will be given 9 assignments to help build your design and fabrication skills.

Weeks 1 - 4: Geometric literacy, 3D modelling, parametric logic, data structures
Weeks 5 - 8: Physical prototyping, digital simulation, calibration exercises

Part II: Design Project Assignment
Part II will focus on a single design assignment which will be carried out in groups of two students. The design assignment helps you apply the skills learned in Part I to a structure incorporating all aspects of design to fabrication

Weeks 9-11: Fabrication logics, representation, design project

SCHEDULE AND ASSIGNMENT OVERVIEW

	Class Date	Class (9-12)	Assignment	Learning Objectives	Due Date	Deliverable Description
Part I: Fundamentals	1 Sep 15	Introduction	A1: Geometric Literacy	Develop geometric literacy; learn to decompose buildings into extrusions, surfaces, openings, and connections	Sep 21	PDF
	2 Sep 22	Rhino Modeling Fundamentals	A2: Building Model	Translate 2D observation into accurate 3D volumetric model; develop Rhino efficiency	Sep 28	.3DM file; PDF

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	3 Sep 29	Grasshopper Basics & Computational Thinking	A3: Parametric Staircase Script	Understand computational thinking; translate manual geometric steps into algorithmic rules	Oct 5	.GH file; PDF
	4 Oct 6	Data Structures	A4: Variable Truss Roof	Understand how data structures control complex geometries and results; learn to manipulate information hierarchies	Oct 13	.GH file; PDF
	Oct 13	No Class - Monday schedule				
Part II: Physical and computational	5 Oct 20	Physical Prototyping	A5: Hanging Chain Models, Jungle Gym, Cable Bridge	Understand physics-based design; gravity as primary design force; how real materials differ from idealized models	Oct 26	Physical models; PDF
	6 Oct 27	Topology & Rule-Based Design	A6: Recreate Physical Model as Rule-Based GH Script	Extract design rules from physical observation; understand topology as design parameter	Nov 2	.GH file; PDF
	7 Nov 3	Form-Finding & Tensile Structures	A7: Tensile Structures with Physical Kit of parts	Understand physics-based design with fabric	Nov 9	Physical tensile models; PDF
	8 Nov 10	Digital Form-Finding & Kangaroo (Final project - A10 introduced)	A8: Digital Form-Finding & Parametric Variations	Understand relationship between physical world and digital simulation; begin thinking about final project options	Nov 16	.GH + Kangaroo file; PDF
	9 Nov 17	From digital to physical	A9: unrolling surfaces; packing/nesting	understand fabrication constraints as design drivers	Nov 23	Fabrication files
Presentations and finals	10 Nov 24	Documentation workshop	-	Documentation strategies	-	-
	11 Dec 1	Design consultations/ workshop	-	-	-	-
	Dec 8	Final presentation 4.500/4.505			Dec 7	A10 due
	Dec 15–17	Final presentation 4.105			Dec 15-17	A10 due

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Policies

Criteria and Grading

Grading will be done based on the 9 assignments and the final group assignment. The first 9 assignments account for 70% of the grade while the final assignment accounts for 30%. All 10 assignments need to be completed to pass the class.

The following criteria will be used for the evaluation of your work, both in terms of helping your progress and in final grading:

- Investigation: How rigorous are your investigations?
- Translation of Investigation: How clear are your findings communicated in your handed in assignments?
- Skill: How well do you understand algorithmic thinking and setting up of models for fabrication?
- Participation: How actively and how constructively are you involved in class discussions and exercises?
- Contribution: To what degree do your findings constitute a contribution to the class, field, or larger context?

A: Excellent - Project surpasses expectations in terms of inventiveness, appropriateness, verbal and visual ability, conceptual rigor, craft, and personal development. Student pursues concepts and techniques above and beyond what is discussed in class.

B: Above Average - Project is thorough, well researched, diligently pursued, and successfully completed. Student pursues ideas and suggestions presented in class and puts in effort to resolve required projects. Project is complete on all levels and demonstrates potential for excellence.

C: Average - Project meets the minimum requirements. Suggestions made in class are not pursued with dedication or rigor. Project is incomplete in one or more areas.

D: Poor - Project is incomplete. Basic skills including graphic skills, modelmaking skills, verbal clarity or logic of presentation are not level appropriate. Student does not demonstrate the required design skill and knowledge base.

F: Failure - Project is unresolved. Minimum objectives are not met. Performance is not acceptable. This grade will be assigned when you have more than two unexcused absences.

<u>Assignments 1-9</u>

You will be given completion feedback in the form of 0 , 50 and 100. This is not a direct reflection of your grade but a measure of completion. All assignments need to be submitted to pass. Meaning 0s need to be made up for and may result in lowering of the grade.

0: Assignment not submitted
50: Assignment is submitted but not all components are completed
100: Assignment submitted and all components completed

You can expect that:

- Submitting all assignments completed (100) would correspond to an A.
- A mix of 100 and 50 may be graded as A or B depending on individual progress.
- All assignments are 50 corresponds to B or C depending on individual progress.

- Any 0 corresponds to fail- all assignments must be turned in. 0s can be made up for by the end the class

Late submission

The due dates of assignments are strict. No extensions will be given. Nevertheless, assignment submission will never be locked, meaning you may always submit a late assignment via Canvas. All your late assignments will be tallied in terms of time. You have a late budget that does not penalize your grade as follows: you are allowed a total of 7 days of late assignments. You may use your 7 days as you wish without it affecting your grade (e.g. one day late for 7 of the 9 assignments; OR one assignment late for a week; OR 2 assignments late for 3 days and one for 1 day etc)

Attendance

Attendance at all class meetings is mandatory. A maximum of 3 absences allowed meaning you are allowed three excused absences for the semester. An excused absence is defined as one that was discussed with and approved by the professor or a family or medical emergency that is confirmed by your physician, or a dean in the Student Support Services. Four absences could mean automatic failure. Please remember to silence cell phones and be courteous when using laptops in class. This course is committed to the principle of equal access. Students who need disability accommodations are encouraged to speak with the faculty member/department administrator early in the semester so that accommodations can be implemented in a timely fashion.

Undergraduates: If anything is getting in the way of your academics, please consult with S3 (s3-support@mit.edu). The walk-in queue is open from 10-12 and 2-4 on weekdays. Appointments can be virtual or in-person, depending on your comfort and convenience.

Graduates: A variety of issues may impact your academic career including faculty/student relationships, funding, and interpersonal concerns. In the office of Graduate Education (OGE), GradSupport provides consultation, coaching, and advocacy to graduate students on matters relating to academic and life changes. If you are dealing with an issue that is impacting your ability to attend class, complete work, or take an example, you may contact GradSupport by email at gradsupport@mit.edu or via phone at (617) 253-4860.

The MIT online course management system (Canvas) will be used together with Slack in the course. Lecture handouts and exercise descriptions will be available there shortly after class is held. Students will also be submitting exercises and materials through this system and must do so by the assigned due date.

Academic Integrity/Honesty

Massachusetts Institute of Technology students are here because of their demonstrated intellectual ability and because of their potential to make a significant contribution to human thought and knowledge. At MIT, students will be given unusual opportunities to do research and undertake scholarship that will advance knowledge in different fields of study. Students will also face many challenges. It is important for MIT students to become familiar with the Institute's policies regarding academic integrity, which is available at *Academic Integrity at MIT: A Handbook for Students.*

AI policy

As a central goal of this class is to help you develop the ability to think through setting up parametric models and the specific relationship between the physical world, it;s digital representation and vice versa, you are discouraged from using AI tools to solve your assignments pertaining to setting up scripts and visual programming. They may be used for creating images, editing drafts or helping brainstorm. Work using AI for these purposes must be cited appropriately.
Any work submitted using AI tools beyond these acceptable uses may be considered a violation of academic integrity, with the possibility of a referral to the Office of Student Conduct and Community Standards (OSCCS).