Syllabus

Special Topics in Computational Design and Fabrication — Fall 2025

Introductory Information

This course explores the core mathematical, algorithmic, and computational principles that drive modern design tools, focusing on digital design representations, generative design, optimization, and interactive exploration. Students will learn to develop computational models for automating design processes, implement algorithms for shape generation and performance evaluation, and integrate digital design with fabrication techniques such as 3D printing, laser cutting, and machine knitting. The course includes hands-on assignments and a final project where students build their own computational design workflow.

Learning Goals

By the end of the course, students will be able to:

- Develop computational models to automate design processes.
- Implement algorithms for shape generation and optimization.
- Bridge digital design with physical fabrication workflows.
- Apply algorithms to evaluate design performance.
- Create domain-specific abstractions for interactive design exploration.

Instructor: Adriana Schulz, She/Her
TA: Jack Zhang, He/Him
Office hours: TBD

Prerequisites

- A good working knowledge of Python programming
- Basic linear algebra (matrices and vectors)
- Some mathematical sophistication
- No prior knowledge of manufacturing is assumed

Communication

- See website for updates on lecture topics, calendar and lecture slides: `TODO:getURLfromBrown`
- Assignments will be posted and submitted via Canvas
- We will use Ed for a discussion board and direct messaging with instructors

Course Materials

- A laptop on which students can run Python code (either locally or through Google Colab) is required for completing homework assignments.
- Students should also be able to install software used in lab sessions, such as OpenSCAD and other free or open-source tools provided during the course.
- Students are responsible for obtaining any additional resources required for their chosen final project, which may involve higher computational power, specific software, or fabrication materials beyond those used in labs. For example, if a student selects a project that involves a specific fabrication technique for which resources are not available through the course, they may need to acquire materials on their own. It is up to students to choose their projects based on the resources they have access to.

1 General Policies

This syllabus is designed to be a guideline for the course and these policies are subject to change.

Grades

- 40% Assignments
- 45% Course Project
- 15% Participation
- No final exam

2 Assignment Policies

- Initial code and libraries will be provided for all assignments. A writeup should be submitted via CANVAS for each assignment, with all code pushed to your course-assigned individual repositories, by the due date.

- **Collaboration policy** Discussions are encouraged but implementations and write-ups must be done *individually*. Students are encouraged to meet up and discuss assignments. They can write ideas or pseudo-code on paper or a whiteboard during discussions but they may *not* take any code or notes away from those conversations. A good rule of thumb is the Gilligan's Island Rule[1]. Please indicate in your writeup any discussion group you participated in.

- **Late policy** Assignments must be submitted by 7:59pm on the listed due date. Late days are measured in periods of 24 hours. You have 5 late days with no penalty for the whole quarter but can use no more than 3 for any given assignment. Beyond this, late assignments will lose 25% credit per day (additive). Days are measured in periods of 24 hours (no special considerations about weekends outside of the fact that the TA may not respond to Ed questions during that period). Please read the details carefully under **"Don't suffer in silence"** below.

3 Course Project Policies

Projects account for **45%** of the total course grade, with **40%** allocated to Project effort and results and **5%** to presentation. Grading projects can be challenging because they vary significantly, making direct comparisons difficult. To ensure fairness and encourage students to take ownership of their learning, our grading approach is designed with two key goals in mind:

- **Fairness** – Ensuring project grading is as objective and equitable as possible.

- **Self-Assessment** – Helping students develop the ability to evaluate their own work, an essential skill in research and industry.

Grading Project Effort (40% of Total Grade)

Total Points Per Team Projects should be completed in groups, and each group is allocated **100 effort points**, which is sufficient for a full score (100%) on the project. Past experience has shown that high-quality projects require about two people, so this is the recommended team size.

If a group has:

- **1 member** → 60 effort points required for a full grade.

- **3 members** → 150 effort points required for a full grade.

[1]The Gilligan's Island Rule: This rule says that you are free to meet with fellow student(s) and discuss assignments with them. Writing on a board or shared piece of paper is acceptable during the meeting; however, you should not take any written (electronic or otherwise) record away from the meeting. After the meeting, engage in a half hour of mind-numbing activity (like watching an episode of Gilligan's Island), before starting to work on the assignment. This will assure that you are able to reconstruct what you learned from the meeting, by yourself, using your own brain.

This ensures that effort points are fairly distributed, regardless of group size.

For example, if the class collectively decides (see **Rubric Design** below) that **10 effort points** is reasonable for conducting experiments that compare results with prior work, then all groups will receive **10 points** for doing so, regardless of their size.

Point Distribution Among Team Members If a **group of three** earns **95 effort points**, members can:

- All receive **95%**, or
- Distribute the points (e.g., one member gets **100%**, another **95%**, and the third **90%**).

Each group member is welcome to email us separately with their assessment of how points should be distributed among members. These emails will be kept **confidential**. We will consider individual feedback when making the final decision on point allocation. If no feedback is provided, points will be distributed **evenly** among group members.

Project Check-ins and Rubric Design

We will have **three project check-ins** during the semester.

Check-in 1: Project Pitch

Purpose: Get early feedback on your project topic and execution plan.

- **Timing:** Early in the semester
- **Format:** A **1-minute** in-class presentation.
- **Deliverables:** A **single slide** added to a shared Google Slides deck (template provided).

Check-in 2: Rubric Pitch

Purpose: Define project scope, effort distribution, and grading criteria.

- **Timing:** Mid-semester, once you have enough progress to define concrete goals.
- **Format:** A **1-minute** presentation with:

Deliverables:

- A single slide added to a shared Google Slides deck (template provided).
- A rubric outlining project components and proposed effort allocation (added to a Google Doc in a shared drive accessible to the whole class).

Details on Rubric Design and Peer Feedback

- The rubric will define what tasks are included in the project and how much effort each is worth.
- Other students will review and provide feedback on rubrics during the presentation to ensure fairness.
- Feedback may include recognizing particularly difficult tasks that should be worth more points or identifying tasks that seem too simple and need additional effort.
- Instructors will also review and adjust rubrics as needed.
- **Once finalized, rubrics cannot be changed.**

Final Presentation & Self-Grading

- **Timing:** Scheduled in **two lectures** at the end of the quarter.
- **Format:** Each team gets a **20-minute slot** (10 minutes for presentation, 10 minutes for Q&A).
- **Deliverables:**
  - Final slides summarizing project work.
  - Project Summary Document, including:
    - The original rubric.
    - A self-assessment indicating what was accomplished under each rubric item and suggested grade (added to a Google Doc in a shared drive accessible to the whole class).
  - The entire class is encouraged to provide comments on self-grading in the document.

Note on Extra Credit

- Students may include challenge goals in their initial rubric as extra credit.
- If students accomplish tasks beyond the original rubric, they may add them as extra credit.

Presentation Credit (5% of Total Grade)

Each check-in contributes to presentation credit, which is graded as follows:

Check-in 1: Project Pitch (20 points)

- 10 points – Clarity of exposition.
- 10 points – Staying within the 1-minute time limit.

Check-in 2: Mid-Quarter Rubric Check-in (30 points)

- 10 points – Clarity of exposition.
- 10 points – Staying within the 1-minute time limit.
- 10 points – Clarity of rubric and summary document.

Final Presentation (50 points)

- 10 points – Clarity of exposition.
- 10 points – Staying within the time limit.
- 10 points – Clarity of rubric and summary document.
- 20 points – Contextualization of the project, including a clear justification of how it compares to the state of the art.

4 Participation Policies

- Engaging in class discussion is essential for one of the key learning objectives of this course: to reflect on computational solutions that will enable the next-generation design tools for manufacturing that fundamentally change what can be made, and by whom. **Since there are no scheduled exams and the coding assignments can only reflect a small portion of the topics discussed in class, the participation grade is designed to reflect this key learning objective.**
- Students will be awarded one participation point for every lecture they are *actively* present, participation is measured using "Duck Points".

  Participating Ducks, or "Duck Points" Each student will receive one rubber duck at the beginning of the quarter, which they should keep and return by the end of the quarter. During each class, the student can throw the duck to the lecturer when they engage in class discussion — engagement means either asking or answering a question. The lecturer will keep the "participating ducks" at the front of the classroom until the end of class. At the end of the class, the TAs will take note of all the ducks that are up front and give their owner students a participation point for that lecture. **Note:** Adriana is known to have no chance at a career as a catcher. You will get your participation point whether or not she is able to catch your duck at the first throw, but she will be very excited if she is able to do it so you should try to make it easy on her ;)
- A full score will be given to students that accumulate at least 16 "Duck Points". Since there are 22 scheduled lectures this semester (project presentation classes do not count), this means that students can be absent for up to 6 lectures with no penalty. Under extenuating circumstances, students will be able to get a participation point

for a missed lecture by submitting a report on the lecture they have missed. See the details under **"Don't suffer in silence"** below.

- There is no extra credit for participation. You can keep track of your grade on CANVAS. Please check CANVAS from time to time and let the TA know if there is a mistake, as these can happen with ducks flying around :).

5 Course Schedule

This schedule is tentative and subject to change. Please check the course website for the most up-to-date version.

Date	Lecture Topic	Notes / Deadlines
09/05/2025	Overview - Admin	
09/08/2025	Design Representations Part 1: Data Structures	Lab 1 out
09/12/2025	Design Representations Part 2: More on Data Structures	
09/15/2025	Design Representations Part 3: Programs	HW1 out
09/19/2025	Design Spaces Part 1: Symbolic Spaces	
09/22/2025	Design Spaces Part 2: Variations from a Single Example	Lab 2 out, Lab 1 Due
09/26/2025	Design Spaces Part 3: Learned Spaces from a Collection	
09/29/2025	Design Spaces Part 3: Learned Spaces from a Collection	HW2 out, HW1 due
10/03/2025	Fabrication Part 1: Generating Machine Instructions	
10/06/2025	Fabrication Part 3: 3D Printing Pipeline	Lab 3 out, Lab 2 Due
10/10/2025	Project Pitches	
10/13/2025	**Holiday**	
10/17/2025	Design Evaluation Part 1: Intro to Simulation	Release HW3 out, HW2 due
10/20/2025	Design Evaluation Part 2: FEA, Learning	
10/24/2025	Design Optimization Part 1: Continuous and Discrete Optimization	Lab 4 out, Lab 3 Due
10/27/2025	Design Optimization Part 2: Topology Optimization	
10/31/2025	Design Optimization Part 3: Multi-Objective Optimization	HW4 out, HW3 due
11/03/2025	Design Optimization Part 4: Bi-level and Bayesian Optimization	
11/07/2025	Project Updates and Rubric Design	Lab 4 Due
11/10/2025	Project Updates and Rubric Design	
11/14/2025	Design Exploration Part 1: Visualization and Interactive Exploration	HW4 due
11/17/2025	Design Exploration Part 2: Inference	
11/21/2025	Design Exploration Part 3: User Feedback	
11/24/2025	Open Problems: Bridging Reality Gap in Simulation	
11/28/2025	**Holiday**	
12/01/2025	Open Problems: Sustainable Manufacturing	
12/05/2025	Open Problems: Accessibility	
12/08/2025	Final Project Presentations	Project Reports Due
12/12/2025	Final Project Q&A	

6 Academic Honesty

Please review the Brown University Academic Code: `http://www.brown.edu/academics/college/degree/policies/academic-code`. All work submitted for grading should reflect your own individual effort. Discussions with other students or the instructors are allowed, but copying is not acceptable. Sharing, copying, or obtaining information from unauthorized

sources during any assessment activities in this class are violations of the code. Misunderstanding of the Academic Code is not accepted as an excuse for dishonest work.

6.1 Use of AI Tools Policy

Students are **encouraged** to utilize AI tools such as ChatGPT and Copilot to support their learning and homework completion. However, any work submitted must be original and must not be represented as the sole product of the student. When employing AI tools, students are required to include a detailed discussion that addresses the following points:

1. **Utilization of AI Tools:**
    - Detail how and where the tool was implemented. Elaborate on why the tool was chosen and whether it helped in achieving the set goals.
    - *Example:* What prompts were utilized to obtain the final result? Were there instances when the tool failed? Was there a need to iterate on prompts? Did the tool reduce development time or aid in resolving impediments? Was it instrumental in overcoming a block?
2. **Interpretation of Results:**
    - Explain the methods used to verify the correctness of the obtained result.
    - *Example:* Could you interpret what the generated code was intended to do and perform a sanity check to ensure it accomplished the goal? Or did you run the code and validate that it worked on the examples provided?
3. **Impact on Learning Experience:**
    - Reflect on how utilizing AI tools affected your grasp of the subject matter.
    - *Example:* Did it allow you to concentrate on core class concepts, such as geometric and mathematical ideas, with the AI handling computational details, or did it hinder learning by solving problems and eliminating the need to engage with key geometric insights?

7 Supporting Students: "Don't suffer in silence!"

We recognize that our students come from varied backgrounds and can have widely-varying circumstances. Our ultimate goal is to help every student be successful in the course. Extenuating circumstances can include physical or mental health and wellness, work-school-life balance, familial responsibilities, military duties, unexpected and unavoidable travel, or anything else beyond your control that may negatively impact your performance in the class. While we want to make sure all students feel comfortable reaching out to the staff under extenuating circumstances, we have two important concerns:

1. People come from diverse backgrounds and therefore may be more or less likely to feel comfortable asking for special accommodations. Policies that set up harsh deadlines but then are flexible to all students who reach out to ask for special accommodation lead to students not being treated equally and can impact students from diverse backgrounds negatively. To this end, we have decided to make policies for handling extenuating circumstances explicit as part of the syllabus. We also designed this policy so that students do not have to disclose specifics of their circumstances to the staff, which may cause additional discomfort.

2. Students who are suffering from extenuating circumstances often require additional support. Brown has many resources in place to support such students and it is our duty as instructors to make sure that students who are struggling do in fact reach out to those resources so that they can get the support they need. Therefore we clearly outline what types of exemptions we are willing to make directly and which ones cannot be granted without the supervision of staff dedicated to supporting students.

We outline such policies below.

Accommodating late assignments beyond the late day policy As previously mentioned you get 5 "free" late days to use throughout the quarter (no more than 3 per assignment). In case of unforeseen or extenuating circumstances when students need more time to finish the assignment beyond the free late days, students should email the staff mailing list, and say:

> "I am dealing with extenuating circumstances and need support for turning in my next assignment. I am already using Y of my "free" late days on this assignment, but I will need X days beyond that, so I am requesting to turn it in on the requested date = [due date + X + Y]. "

This request will be granted if the staff is able to accommodate the extra burden of grading (date $\leq$ March 13) and if one of the following is true:

- $X \leq 3$ and this is the first or second time in the quarter the student has reached out requesting extra time for an assignment. (This should support students who are struggling with a one-off unenforceable circumstance but do not require additional support).

- We receive an email from SAS requesting special accommodations (This should support students who need special accommodations.)

- An academic advisor (or equivalent from another department) is cc'ed in the email and follows up to say "I have been in touch with the student and I am working with them to support them in this extenuating circumstance. I think it is appropriate for the Staff of CSCI 2952Y to grant this exception if it is possible." (This should support students are dealing with extenuating circumstances but have reached out to the Brown resources and are getting the appropriate support). I you need help getting in touch with advising, we would be happy to assist.

- A research advisor (or another faculty mentor within Brown) is cc'ed in the email and follows us to say "I am aware of this request and think it is appropriate for the Staff of CSCI 2952Y to grant this exception if it is possible." (This should support students who need special accommodations but are getting the appropriate support from another faculty mentor.)

Policy for accommodating missed lectures: If you have to miss lectures and want to make up for participation grade, you can submit a report on the lecture that you missed. Please note that we cannot guarantee that recordings will be available and you may need to reach out to colleagues or the TA for help understanding the lecture you missed. In case of unforeseen or extenuating circumstances, student should email the staff mailing list, and say: "Because of personal circumstances, I had to miss class X and I would like to submit this report (attached) to show that I understand the material that was covered." Please *include* the TAs and do *not* disclose the specific circumstances in your email. All reports must include all topics discussed in the class, and must be submitted by March 13. We will accept up to 5 reports. If you need to submit more that 5 reports (that means you will miss more that half of the quarter), we recommend you contact the advisors or SAS.

Policy for accommodating missed labs: Missed labs are very hard to make up and students will definitely miss out on the experience, so we urge students to try their very best to attend labs. That said, we will allow students to submit a report for a missed lab. In case of unforeseen or extenuating circumstances, student should email the staff mailing list, and say: "Because of personal circumstances, I had to miss lab X and I am submitting my report with extra details to show I understood what the lab was about." If you need to miss more than ONE lab, we recommend you contact the advisors or SAS.

Accessibility and Accommodations

Your experience in this class is important to us. If you have already established accommodations with student accessibility services (SAS), please communicate your approved accommodations to the instructor at your earliest convenience so we can discuss your needs in this course. If you have not yet established services through SAS, but have a temporary health condition or permanent disability that requires accommodations (conditions include but are not limited to: mental health, attention-related, learning, vision, hearing, physical or health impacts), contact SAS directly to set up an Access Plan. SAS facilitates the interactive process that establishes reasonable accommodations.

Lecture Recordings

This course is scheduled to be fully in-person, but lectures will be recorded. Because technical issues with recordings may arise, we cannot guarantee that all lectures will be made available offline and therefore students are strongly encouraged to attend classes unless they are unable due to extraordinary circumstances.

Privacy Note: The recording will capture the presenter's audio, video, and computer screen. Students' voices during lecture will be captured in the recordings.