Dalhousie University | School of Architecture

ARCH 4502.03 | B5 Representation | Winter 2025
Monday 2:30-5:30p | Room: B227

Instructor: Elizabeth Powell she/her NSAA Architect [**eepowell@dal.ca**]
Office hours: by appointment, email Elizabeth to setup a virtual meeting
Teaching Assistants: Jackson Senner **jackson.senner@dal.ca**

Land acknowledgement

Dalhousie University sits on the Traditional Territory of the Mi'kmaq. We are all Treaty people.

Calendar description

This course studies advanced strategies of representation. It promotes the fluent use of digital media in conceptual design development, guided by architectural intentions and an understanding of architectural theory and technology.
Course Format: Lecture, Studio | Credit Hours: 3 | Restrictions: Year 4 BEDS Students

Course description

Definitions:

Parametric modelling is a method of design wherein forms are generated through an algorithmic definition, rather than directly drawn, or modelled. Using even a simple set of rules and relationships designers will create increasingly complex forms and structures. This systems-based method of form-finding allows architects to use variable inputs and large datasets to quickly explore iteration, creating highly malleable, and adaptable designs. Forms created this way by their nature embrace diversity and complexity; forms adapt to site conditions, fenestration adapts to the light, façade patterns respond to data collected on arctic temperature. Parametric designs can be optimized for manufacturing constraints or let wild when combined with digital manufacturing techniques.

Description:

This course offers students the opportunity to pursue advanced formal concepts through an iterative process of digital design, modelling, and fabrication. This course advances knowledge and skills in 3D design modelling, introducing, and integrating parametric modeling into form making using Rhino and Grasshopper.

The parametric modelling course introduces the approach of building 'systems' to create objects rather than objects themselves, allowing for a wider range of design exploration and iterative production. The course will demonstrate opportunities for interpreting large datasets into form, creating data-driven outcomes, and will teach students how to evaluate iterative design systems against initial project intentions and the emergent qualities realized through the design process.

Students will learn to code and represent complex geometry using Grasshopper. They will explore, learn, and develop generative design systems, allowing for iterative material outputs. Knowledge will be presented through case studies, translating of form into coded processes. This coding methodology of interpreting complex forms as processes will be reinforced by practiced application in the students' formal explorations using Rhino and Grasshopper. Once defined, a small series of models will be produced, accessing a variety of digital fabrication methods, including 3D printing, laser cutting and CNC

milling. Throughout the course representation techniques will be advanced using methods of allegorical diagramming, rendering, and technical drawing techniques.

Learning Objectives

- Understanding the principles of parametric modeling - form as process
- Parametrically generate ranges of complex geometric objects through digital coding –systems of forms
- Develop methods for interpreting datasets into formal objects – form from data
- Represent and Prototype virtual objects with two-dimensional technical drawings and renderings, and physical prototypes using 3D printing, laser cutting, CNC milling, and other digital fabrication methods – material into form
- Evaluating design representations against initial project intentions and the emergent qualities realized through the design process in a supportive and collaborative studio environment – form to inform

Rationale

This is the final course in the undergraduate Representation stream. It assumes knowledge of fundamental modes and techniques of representation. It extends existing knowledge and introduces innovative techniques for communicating design.

Format

The course will consist of weekly lectures and work-in-progress pin-ups and discussions. Project reviews will take place in the Exhibition Room and Project submission in the format of a digital upload to the course Brightspace page. The lecture notes will be provided on Brightspace and students may record the lectures.

Hours

Students are expected to devote 9 hours per week - including class time - to the course. If most students are spending significantly more time than this, inform the instructor and adjustments will be made to the workload.

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Course schedule

Academic Dates	Lecture subjects	Pin-up	Submission	Value
06-Jan-25	Instructor introduction, course format and expectations, Introduction to parametric modelling - iterations, move, extrude, trim, copy, array, twist Assignment 1 introduction and discussion			
	No classes - professional practice week			
20-Jan-25		Pin-up and discussions	Assignment 1 - Form as process	20%
7-Jan-25	Grasshopper tutorial 1 - point line plane volume (move, extrude, trim, copy, array, twist) Intro Assignment 2			
03-Feb-25	Grasshopper tutorial 2 - subdivision, gradation, attractors/reactors, mapping, remapping			
10-Feb-25	Grasshopper tutorial 3 - data manipulations: site data, environmental data, human data			
	No classes – winter break			
24-Feb-25	Grasshopper tutorial 4 - make 2D, data trees, evaluate, physics generator, overflow and desk crits			
03-Mar-25		Pin-up and discussions	Assignment 2 - Systems as forms	45%
10-Mar-25	Renderings lecture (sky, scale, story), Exploded axonometric assembly drawings, and drawings for fabrication (lists, numbering, line weights)			
17-Mar-25	Renderings working session			
24-Mar-25	Detail working session SLEQ			
31-Mar-25	Last class	Pin-up and discussions	Assignment 3 - Form as material	35%

Text and readings

The course bibliography is for general reference only. Texts and research material will be cited in course lectures in reference to specific course projects and it is expected that individual students will pursue further research through online resources according to their interests and needs. Excerpts from cited texts will be available on the course Brightspace.

There are three good Grasshopper Primers available on Brightspace, and one slightly more advanced text on Essential Algorithms and Data Structures. There are also a suite of basic grasshopper and rhino files that will be referenced in the course that will act as a coding starter-pack.

- Burry, Jane., and Mark. Burry. The New Mathematics of Architecture. London: Thames & Hudson, 2010.
- Young, Pyo Mi. Architectural Diagrams. Berlin: Dom, 2011.

Equipment and Software

Students should have access to a workspace, materials, and tools to permit manual drawing and model making. A computer is required and should have installed a working copy of the following software:

- Rhinoceros with Grasshopper (required)
- Image processing (photoshop, or Gimp)
- Compiling and presentation (InDesign, Acrobat)

Grasshopper Plug-ins: Food4Rhino (http://www.food4rhino.com/grasshopper-addons)

SLEQ

Student Learning Experience Questionnaire will be scheduled on March 27, 2023, during class time.

Submissions

Work is due as indicated in the course schedule. Work will be presented on hard copy form in project reviews during class time on the due date and submitted digitally uploaded to the appropriate folder in the course website on the designated due dates at 11:59pm. The format of each submission will be specified in project outlines. All submissions must follow the following naming convention:
last name_first name_project name

Assessment

All work is expected to demonstrate understanding of the principles and objectives underlying each project and assignment. Completion of each project will involve focused and sustained study and should be presented as a coherent and finished piece. Work should be created and maintained in consideration of the objectives of the “Process Portfolio” outline.

All assignments will be graded by the instructor and comments will be provided in written format.

Criteria for assessment

Completed work will be graded by the instructor based on fulfillment of project requirements, technical skill, clarity, and evidence of intentions. Assessment will be based on specific deliverables for each project and each assigned part of a project. This will be specific to media, software for each project and assignment. Additionally, as a research-based course, deviations from the set criteria may arise as individual projects evolve. These changes should be discussed with the instructor in advance of due dates.

Assessment for all submissions will be based on:

- understanding the conceptual and practical material and basis of each assignment
- evidence of conceptual thinking and evidence of research through each assigned part
- engagement with the subject matter in each assignment
- evidence of technical skill and appropriate representational mode
- quality of presentation of work, ie. completeness, effectiveness of presentation formats, appropriate use of notations, texts, other media

Grade scale and definitions

Grade	Grade	Point	Definition
A+	90-100	4.30	Excellent. Considerable evidence of original thinking; demonstrate outstanding capacity to analyze and synthesize; outstanding grasp of subject matter; evidence of extensive knowledge base
A	85-89	4.00	
A-	80-84	3.70	
B+	77-79	3.30	Good. Evidence of grasp of subject matter, some evidence of critical capacity and reasonable understanding of relevant issues; evidence of familiarity with the literature
B	73-76	3.00	
B-	70-72	2.70	
C+	65-69	3.20	Satisfactory. Evidence of some understanding of the subject matter; ability to develop simple problems; benefiting from his/her university experience
C	60-64	2.00	
C-	55-59	1.70	
D	50-54	1.00	Marginal Pass. Evidence of minimally acceptable familiarity with subject matter, critical and analytical skills
F	0-49	0.00	Inadequate. Insufficient evidence of understanding of the subject matter; weakness in critical and analytical skills; limited or irrelevant use of the literature
INC		0.00	Incomplete
W			Neutral and no credit obtained Withdrew after deadline
ILL			Neutral and no credit obtained Compassionate reasons, illness

Course specific policies

sources

Guidelines for citing sources in Chicago author-date style can be found at: tinyurl.com/dal-arch-writing, Chicago Manual of Style quick guide: http://tinyurl.com/chicago-author-date

academic integrity

Students are expected to complete course assignments individually. Graphic submissions are not subjected to analysis by plagiarism detection software. The originality and integrity of work depends on the ethics of each student.

Due Dates and Late Submissions

Deductions for late submissions encourage time management and maintain fairness among students.

	Due Date	Is a late assignment accepted?	If so, what is the deduction per weekday*?	Is there a final deadline for a late submission?	What happens after that?
Assignment 1 – Form as Process [20%]	January 20, 2025	Yes	3%	January 27, 2025	Receives 0% and no comments
Assignment 2 – Systems as Forms [45%]	March 3, 2025	Yes	3%	March 10, 2025	Receives 0% and no comments
Assignment 3 – Form as Material [35%]	March 31, 2025	Yes	3%	April 7, 2025	Receives 0% and no comments

* For example, if an assignment is evaluated at 75% before applying a 3%-per-weekday deduction, it would receive 72% for being 1–24 hours late; 69% for 25–48 hours late; etc.

Note:

The following University or School policies take precedence over course-specific policies:

- No late assignments are accepted after the last day of weekly classes (the Friday before review week).
- With a Student Declaration of Absence (maximum two per course), an assignment may be submitted up to three weekdays late without penalty. An SDA cannot be used for the final assignment.
- With a medical note submitted to the School office, a course assignment (including a final assignment) may be submitted more than three weekdays late without penalty. The number of weekdays depends on how long you were unable to work, as indicated in the medical note. If more than one course is affected, you should consult with the Undergraduate/Graduate Coordinator to set a new schedule of due dates.
- A student with an accessibility plan that allows for deadline extensions does not need to submit an SDA.

Faculty Policy

Equity, Diversity, and Inclusion

The Faculty of Architecture and Planning is committed to recognizing and addressing racism, sexism, xenophobia and other forms of oppression within academia and the professions of architecture and planning. We, the faculty, are working to address issues of historic normalization of oppressive politics, segregation, and community disempowerment, which continues within our disciplines today.

university policies and resources

This course is governed by the academic rules and regulations set forth in the University Calendar and the Senate. See the School's "Academic Regulations" page (tinyurl.com/dal-arch-regulations) for links to university policies and resources:

- Academic integrity
- Accessibility
- Code of student conduct
- Diversity and inclusion; culture of respect,
- Student declaration of absence
- Recognition of Mi'kmaq territory
- Work safety
- Services available to students, including writing support
- Fair dealing guidelines (copyright)
- Dalhousie University Library.

Assignment 1: Form as Process

The first assignment is a study of precedent and parametric thinking. In this first exercise students will find examples of realized parametric designs and dissect the forms as a process of modelling. The intent of the assignment is to begin to critically evaluate complex geometry/pattern into simple steps (create a surface, subdivide, find the center of each cell, move, rotate, scale, etc) that can be brought into grasshopper and coded. This is a form of reverse engineering that we will collectively review as a class and discuss the common techniques and practices of parametric design. At the end of this assignment students will be introduced to parametric thinking, the basic building blocks of coding in grasshopper, using simple diagrammatic representations to communicate process, and common terms in parametric design.

Assignment submission: January 20, 2025 – Pin-up and discussion

Students will pin-up the source precedent image/images and a series of diagrams outlining the potential steps that could be used to create the form/pattern. Students may choose to do this using hand drawn diagrammatic sketches, photoshop collage or computer modelled diagrams. The precedent image and diagrams are to be laid out on (1) to (2) 11x17 page and pinned up on the wall for discussion. Students are not expected to present their work individually but may be called upon to talk about their drawings or methodology as part of the class discussion.

The pin up will be accompanied with approximately 250 words included on the printed page (no more than 500 – this is intended to be brief) describing what interested you in the precedent image. It is a completely valid answer to say ‘I thought this looked cool’ but try to articulate why you feel that way ‘I thought this looked cool because of the dappled light, or I could see using this to create a solar shade, or it would make a really big space feel small and compressed’

Students may choose to work individually or in groups up to (5) people. With that said, if students are working in groups, they are required to present the same number of distinct precedent image examples as there are in the group. If there are three people there are three precedent images to start the exercise from, if there are five people then there are to be five precedent images, if there is one person there is one precedent image. Students in groups will each receive the same mark as the group.

The one-to-two-page submission will include the student’s name and student ID number, the names of all students in the group (if applicable) and give it a plucky title if you’re so inclined. Elizabeth (the instructor) will be taking these pages at the end of class, so please scan all originals and keep those for yourself.

Grading:

Students will be evaluated on the following criteria:

Citation for the image – find the photographer, architect or artist and provide citation	3 points
Quality of analysis of form/pattern into distinct modelling processes.	5 points
Clarity of process diagrams and composition of information on one-to-two-page submission to describe precedent image. Diagrams will be evaluated on use of line weight to demonstrate form, and use of color and graphic elements (such as arrows, etc.) to indicate important elements/features, show movement or change, and represent narrative.	10 points
Inclusion of approximately 250-word description of why this image was selected.	2 points

This submission is worth 20% of the overall grade for the class. Refer to course outline for late submission guidelines.

Assignment 2: Systems of Forms

Architecture is the science of relationships; how a roof meets the elements, a wall meets the floor, the building touches the ground, the hand meets a handle. Architecture composes these relationships to guide focus and tell a story through design. In this second assignment students will iteratively study an architectural relationship using parametric modelling skills developed in the course. The goal is to use data [examples: urban conditions, environmental parameters, biomechanics, etc,] to explore the design of an architectural element.

The iterations created in this assignment will be used to generate a series of diagrams to communicate the design process and the influence of the relationship. The evaluation of this assignment will be based predominately on the success of these diagrams to clearly communicate the relationship and the process used to generate design iterations. This course will teach students how to code form/pattern using rhino/grasshopper, however the evaluation will be based on the use of diagrams to communicate design process. The successful completion of this assignment is not predicated on creating fully functional grasshopper code. Grasshopper is a powerful design tool, but if it's not for you that is perfectly fine. There are many ways to explore design iteration and the lessons on generating forms through process will be applicable regardless of the tools used to create the diagrams.

It would be advantageous for students to choose an element that can become part of their Design course, but this is by no means a requirement. This work is to be done and submitted individually, but students are encouraged to collaborate, help each other with troubleshooting and share coding resources. Grasshopper knowledge is built on an open-source community. Helping each other makes us all better. Just remember to give credit and cite all resources. This can be tough with online discussion resources, so at a minimum list the website, and date the resource was created.

Step 1: Pick 'n' Choose a relationship to study

Students will be tasked with selecting a relationship to study (canopy to shade, bench and body, the compression of walls and movement, etc) and placing them in a context (canopy over a courtyard, bench in front of art, the procession between galleries, etc). Write out a short description of approximately 500 words and with up to (2) precedent images to illustrate the relationship and the context, and the types of parametric explorations you intend to use to study this relationship.

Students are encouraged to make this decision quickly and may choose to submit a word file with their images on February 6, for review and commentary. This will not be a graded submission at the time, but a good opportunity to check in and receive suggestions for code resources.

Try not to overthink the relationship you are studying. My philosophy is that one of the skills you should develop as an architect is to use design to make things good, which is to say that great ideas are rarely conceived in their final form from the start, and instead are built up through the design process. The idea is to start with something relatively simple and throughout the course build complexity and interest into it. This exercise is intended to give you something interesting to focus on so you can learn parametric

modelling techniques and not get bored, so if you find yourself spinning your wheels on what to do chat with the instructor. I have lots of ideas on how this project could be done and I will guide you if you're stuck.

Step 2: Create a system for making forms/patterns

Using the parametric skills developed in the class students will create an initial parametric framework for creating their forms/ patterns. Examples of this would be to create a series of curves in rhino or grasshopper that are lofted into a form. As the curves are manipulated and adjusted a new version of the form is created. Students should focus on creating iterations of form/patterns. During the desk crits on February 13th, the instructor will come by and provide feedback on these initial iterations. Students may choose to submit their codes and rhino files on this day for commentary and to get help with troubleshooting codes.

Step 3: Infuse with data

Use data to inform the manipulations. This is where you add into the code data collected about what your architectural element is relating to, as an example: wind patterns, dimensions of various bodies in sitting positions, frequency of buses that pass by the entrance throughout the day. The goal is to see how the data changes the form. Data and initial code explorations may be submitted on March 6th for review and commentary.

Step 4: Represent

Represent your work. Generate a series of diagrams (like the types of diagrams created for assignment 1) to explain your process for creating your form/pattern. This series of diagrams should represent in simple terms the system you created for generating forms with data.

Show the series of iterations your codes yielded with the coded systems you created. This should be between 5 and 15 examples of the forms/patterns you created.

Present the work on up to (6) 11x17 sheets. Include name and student ID on each sheet, the 500-word description of relationship you studied with up to (2) precedent images, a screenshot of the code, diagrams illustrating the process for creating the forms/patterns, diagrams illustrating the relationship between the data and the form and the iterations of the forms/patterns.

Pin-up your work in the exhibition room on March 13th for review. The main topics of discussion on this day will be:

- Did your initial hypothesis of the things you wanted to study yield expected results?
- Based on the type of relationship you were studying how would you select one of these objects to build?
- Were there any emergent properties that came from the study that you were not expecting?

Assignment Submission - March 03, 2025

Submit a PDF of your presentation pages, and the rhino/grasshopper files to Brightspace by 11:59pm on March 11th.

Grading:
Students will be evaluated on the following criteria:

Clarity of the approximately 500-word description of the relationship and the context	5 points
Clarity of the diagrammatic description of the system for creating form/pattern Diagrams will be evaluated on use of line weight to demonstrate form, and use of color and graphic elements (such as arrows, etc.) to indicate important elements/features, show movement or change, and represent narrative.	15 points
Clarity of diagrams to explain relationship between data and form/pattern and the iterations of forms/patterns. Diagrams will be evaluated on use of line weight to demonstrate form, and use of color and graphic elements (such as arrows, etc.) to indicate important elements/features, show movement or change, and represent narrative.	15 points
Participation in the pin-up and discussions	5 points
Submission of Grasshopper Code and or Rhino file – use naming convention Last name_First name_Rhino / Grasshopper	5 points

This submission is worth 45% of the overall grade for the class. Refer to course outline for late submission guidelines.

Assignment 3: Material into Form

Create (1) digital rendering of the architectural element created in Assignment (2) and either a detailed drawing showing how the object is constructed or a physical model of the object or pattern.

The intent of this assignment is to represent how complex geometry is constructed and a rendering to express the relationship between the architectural element and the context.

Part 1: required

Students will create one digital rendering of the architectural element created in Assignment 2.

Renderings must include people or other relevant object for scale. The purpose of renderings is to elicit the mood/feelings/vibes one might experience with this architectural element. Students will make use of sky (moody, bright, raining, foggy, snowing, etc.), people (in motion, static, indifferent, etc), and other graphic elements (graffiti, plants, animals, etc) engaging with the architectural element in a photo collage or fully digital rendering.

Part 2: choose A or B – you can do both 2A and 2B if you're so inclined, but there are no extra marks

Part 2A: Students will create assembly diagram(s) to illustrate how the architectural element is created – exploded Axonometric drawings, templates, folding patterns, etc.

Part 2B: Students will create a physical model of the architectural element. For the purposes of the submission on Brightspace take a photograph and upload it – keep the actual model for yourself.

Assignment Submission – March 31, 2025

Submit a PDF of your presentation rendering and either the assembly diagram(s) or photo(s) of the physical model to Brightspace by 11:59pm on April 1rd.

Grading:

Students will be evaluated on the following criteria:

Part One	
Use of sky/context to create atmosphere	5 points
Use of people/animals/ relevant objects to show scale	5 points
Use of other graphic elements add to narrative	5 points
Part Two	
Clearly communicate architectural detail/assembly through physical model or exploded axonometric diagram	15 points
General	
Submission of presentation pages	2 points
Participation in the pin-up and discussions	3 points

This submission is worth 35% of the overall grade for the class. Refer to course outline for late submission guidelines.