Parametric Space and Material Systems

Class Meeting Times
Mondays: 9:30pm – 12:30pm // 1:30pm - 5:30pm
Thursdays: 9:30pm – 12:30pm // 2:00pm - 5:30pm

Studio Director: Maya Przybylski
mmprzyby@uwaterloo.ca
Office hours (by appointment)

INTRODUCTION

The ParaMat studio offers students the opportunity to become immersed in digital capabilities not as production tools but as design media. The studio offers an introductory exploration of computational design by instilling an awareness of structures, processes and opportunities necessary to develop a design practice inclusive of computational strategies and techniques.

Particular emphasis is placed on the relationships between parametric and material systems. Through the course project sequence, the studio will aim to nurture two distinct exploratory environments. The first, *Parametric Space* will focus on the exploration of the abstract structures and processes used to define and characterize parametric models and systems. The second, *Material Systems*, will place physical and tangible materials and their associated ways of making at the center of an exploration of form, material and performance.

The relationship between these two environments will evolve over the course of the term and be explicitly tested in a third phase of work focused on the design of an architectural space guided by the intersection of parametric and material systems. Through this collision, the studio will simultaneously deliver a foundation in computation *and* test what opportunities emerge from including it in an architectural project. On the one hand, introduction to and operation within an unfamiliar domain such as design computing requires a commitment to skills-based instruction where students can learn the conceptual and technical frameworks of the discipline. On the other hand, the traditions of the design studio will require that students engage in their projects in a critical, robust and rigorous manner.

The studio is structured in such a way that previous exposure to writing/reading code is not required.

Students are encouraged to work on the studio project in teams of two.

STUDIO/LAB STRUCTURE

The studio operates as a hybrid laboratory where the traditional model of a design studio is coupled with intensive workshop environments dedicated to fundamental coding paradigms and techniques, explorations of parametric modelling platforms and more advanced exploration of digital fabrication tools. In order to encourage both the acquisition of new techniques and skills, and the ability to develop projects informed by critical and conceptual thought, the studio is organized into two parallel streams:

STREAM A: WORKSHOPS

During the first half of the term, one studio day each week will consist of intensive workshop sessions where students will develop the fundamental skills necessary to engage with the computational design discourse while building on their digital fabrication capacities.

The goal for these working sessions is to allow for the students to become fully immersed in the conceptual frameworks and technical realities of working within a computational discourse. These sessions will move through basic coding components and culminate in the students' ability to develop custom algorithms as a generative tool in the deployment of parametric design solutions. Both traditional coding and visual coding techniques will be explored.

Specific topics/themes explored are:

Algorithms: Variables + Script Structure	Logical Operators
Functions	Conditional Execution
Lists	Repetition
Stochastic Search	Non-Deterministic Execution - Randomness
Geometry	Recursion

STREAM B: STUDIO PROJECT

The studio project is conceived as one term-long exercise unfolding in three distinct stages:

Focus 1: Parametric Space (4 weeks)

The students will develop skills in conceptualizing, structuring, defining and exploring a parameterized system. Taking documentation of a real-world, observable phenomenon as a point-of-departure students will design an inter-related system, of components to comprise a parametric system.

During this work, students will:

> Translate quantitative observations into discrete and relational representations

> Explore the space of parameterization as a creative design medium

> Translate parameterized relationships into structured procedural methods

> Implement custom scripts of code to capture the character and support an exploration of parametric space

Focus 2: Material Systems (4 weeks)

Intended as a response to the abstract character of the previous phase, Part 2 prioritizes investment in understanding and manipulating physical materials through making. Reflecting on their original documentation or the resulting representations of their parametric system, students will work with a specific physical material and a way of making that shares intuitive links to their earlier work. Students will then become immersed in explorations in physical making and reflection through the creating of an iterative series of prototypes.

During this work, students will:

> Build skills in advancing work through observation and synthesis

> Become highly proficient in a particular way of making

> Engage material systems in critical ways to advance an iterative series of prototypes

> Curate an understanding about the opportunities, affordances and constraints of a specific material system

> Formulate a parameterized understanding of the resultant material systems

Focus 3: ParaMat Synthesis (4 weeks)

Part 3 will allow students to combine their new capacities in parametric and material systems into the design for a modest (in scale) architectural space. Students will critically and synthetically respond to their earlier work in order to test how spatial design projects can advance by foregrounding material systems and their parameterization as key drivers. This phase of work is set to complement more traditional studio models where design is driven first and foremost by site and programmatic concerns.

During this work, students will:

> Synthesize previous work into a compelling design strategy reflecting on potentials of parametric design and/or material systems

> Manage the secondary influence of site and program on design outcomes

> Translate small-scale prototypes from Part 2 into architecturally scaled implementations

> Design a small-scale architectural space which integrates themes extracted from the earlier exercises.

Detailed descriptions of each phase will be introduced with accompanying lectures and discussions.

...continued

ADDITIONAL GOALS & OBJECTIVES

The studio will expose students through the curricula to the following objectives and successful completion of the studio term will demand that you skillfully demonstrate knowledge of and engagement with the objectives listed below.

> Engage critically in current design culture by gaining an understanding of the possibilities, potentials and limits of digital techniques and computational design strategies

> Expand notions of authorship within an architectural context to include concepts such as designing-the design. Develop a criticality with respect to these expanded notions.

> Develop translational capabilities from focused observation, to the conceptual and the intuitive, to built work through to constructed research in the form of iterative physical constructions.

> Tune spatial conceptualization and design skills through iterative exploration of computation techniques, physical modeling and material studies.

> Advance representational capacity through drawing and diagramming focusing on organizing and rendering legible conceptual structures and specific areas of inquiry within a broader body of work.

> Explore methodologies, both qualitative and quantitative, of data extraction, organization, and structure.

> Examine and experiment with computational techniques in the context of architectural design: scripting, digital modeling, parametric design, time-based simulations, and digital fabrication

> Identify and explore opportunities offered by non-deterministic/emergent yet controlled design strategies.

> Experiment with digital workflows in order to create 2-dimensional and 3-dimensional representations, diagrams and fabricated artifacts of computationally generated design schema.

TECHNOLOGICAL PLATFORMS + ACCESS

While there are numerous platforms suitable for the introduction of such techniques, we will be primarily working in a suite of tools built around Rhino – RhinoPython and Grasshopper will be the primary platforms used in the exploration of generative algorithms.

While the computer lab at the school is equipped with Rhino, it is recommended that students have a copy of Rhino6 on their laptops/studio computers. Grasshopper is bundled with Rhino6.

USEFUL LINKS:

RhinoPython101
https://developer.rhino3d.com/guides/rhinopython/

General Rhino / Grasshopper Info
Rhino: http://www.rhino3d.com/
Grasshopper: http://www.grasshopper3d.com/

STUDIO COSTS

In addition to the typical costs associated with studio work (printing, plotting, and model making), the ParaMat Studio requires intensive material explorations that have material and machining costs associated with them. It is expected that students can purchase required materials to support these explorations. The opportunity for students to work in pairs presents opportunities to reduce individual costs. Please budget $500/student for the term.

RECOMMENDED READINGS

Beorkrem, Christopher. *Material strategies in digital fabrication*. Routledge, 2013.

Burry, Jane. Burry, Mark. *The New Mathematics of Architecture*. Thames & Hudson. 2010

De Landa,Manuel. Material Complexity in Digital Tectonics. Chichester: Wiley Academy, 2004, S. 21.

Gershenfeld, N. 2012. "How to make almost anything: The digital fabrication revolution". In Foreign Affairs, 91, 43-57.

Iwamoto, Lisa. *Digital Fabrications: Architectural and Material Techniques (Architecture Briefs)*. Princeton Architectural Press. 2009.

Aranda, Benjamin. *Tooling*. Ed. Chris Lasch. 1st ed. ed. New York: Princeton Architectural Press, 2006.

Manufacturing Material Effects: Rethinking Design and Making in Architecture. Ed. Branko Kolarevic and Kevin Klinger. New York: Routledge, 2008.

Menges,Achim. Ahlquist, Sean. *Computational Design Thinking*, AD Reader. Wiley, 2011

Menges, Achim, Tobias Schwinn, and Oliver David Krieg, eds. *Advancing Wood Architecture: A Computational Approach*. Routledge, 2016.

Menges, A.: 2008, Integral Formation and Materialisation: Computational Form and Material Gestalt, in B. Kolarevic and K. Klinger (ed.), Manufacturing Material Effects: Rethinking Design and Making in Architecture, Routledge, New York, pp. 195–210.

Architectural Geometry. Ed. Helmut Pottmann and Daril Bentley. 1st ed. ed. Exton, Pa.: Bentley Institute Press, 2007.

Reas,Casey. McWilliams, Chandler. *Form+Code in Design, Art, and Architecture (Design Briefs)*. Princeton Architectural Press. 2010.

From Control to Design : Parametric/Algorithmic Architecture. Ed. Tomoko Sakamoto and Albert Ferré. New York: Actar-D, 2007.

Schindler, C.: 2008, Information-Tool-Technology (Translation of: Die Mittel der Zeit - Herstellungsinnovation im Holzbau), in Hensel, M., Menges, Form Follows Performance: ZurWechselwirkung von Material, Struktur, Umwelt, ArchPlus No. 188, ArchPlus Verlag, Aachen. (ISSN05873452)

Terzidis, Kostas. *Algorithmic Architecture*. 1st ed. ed. Burlington, MA: Architectural Press, 2006.

Tufte, Edward R., 1942-. *Envisioning Information*. Cheshire, Conn.: Graphics Press, 1990.

Tufte, Edward R. *The Visual Display of Quantitative Information*. Cheshire, Conn.: Graphics Press, 1983.

ARCHITECTURAL DESIGN JOURNAL -- SEVERAL ISSUES INCLUDING:

Material Synthesis: Fusing the Physical and the Computational. Volume 85, Issue 5, July/August 2015

Computation Works: The Building of Algorithmic Thought, Volume 83, Issue 2, July/August 2013

Material Computation: Higher Integration in Morphogenetic Design, Volume 82, Issue 2, July/August 2012

The New Structuralism: Design, Engineering and Architectural Technologies, Volume 80, Issue 4, July/August 2010

Patterns of Architecture, Volume 79, Issue 6, November/December 2009

SCHEDULE

		MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY		
WEEK 1	7 SEPTEMBER	2	3	4	5 AM Option Studio Pitches Location: TBD PM Course Intro, Project 1 Intro Location: E-Classroom	6	7	WEEK 1
WEEK 2	8	9 AM/PM Lab | Python 1 + 2 Location: E-Classroom	10	11	12 AM/PM Desk Crits Location: Studio	13	14	WEEK 2
WEEK 3	15	16 AM / PM Lab | Python 3 + 4 Location: E-Classroom	17	18	19 AM/PM Desk Crits Location: Studio	20	21	WEEK 3
WEEK 4	22	23 AM/PM Project Coding Session Location: E-Classroom	24	25	26 AM/PM Desk Crits Location: Studio (Coding session if needed)	27	28	WEEK 4
WEEK 5	29	30 **PART 1 DUE** **AM /PM** **PART 1 REVIEW** **LOCATION:** **LOFT GALLERY** Part 2 Intro	1 OCTOBER	2	AM/PM Lab | Grasshopper 1 Location: E-Classroom session runs 9:30AM - 4:00PM	4	5	WEEK 5
WEEK 6	6	7 AM/PM Lab | Grasshopper 2 Location: E-Classroom	8	9	10 AM/PM Desk Crits Location: Studio	11	12	WEEK 6
WEEK 7	13	14 **THANKSGIVING DAY NO CLASSES**	15 **READING WEEK** No Classes Scheduled	16	17	18	19	WEEK 7

Schedule Continued...

		MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY		
WEEK 8	20	**21** AM/PM Desk Crits Location: Studio	22	23	**24** AM/PM In-Progress Pin-up Group Session Location: Loft Gallery	25	26	WEEK 8
WEEK 9	27	**28** AM/PM Desk Crits Location: Studio	29	30	**31** AM/PM Desk Crits Location: Studio	1 NOVEMBER	2	WEEK 9
WEEK 10	3	**4** **PART 2 DUE** **AM /PM** **PART 2 REVIEW** **LOCATION:** **LOFT GALLERY** Part 3 Intro	5	6	AM/PM Desk Crits Location: Studio	8	9	WEEK 10
WEEK 11	10	**11** AM/PM Desk Crits Location: Studio	12	13	**14** AM/PM In-Progress Pin-up Group Session Location: Loft Gallery	15	16	WEEK 11
WEEK 12	17	**18** AM/PM Desk Crits Location: Studio	19	20	**21** AM/PM **Part 3 Mid-review** Group Session Location: Loft Gallery	22	23	WEEK 12
WEEK 13	24	**25** AM/PM Desk Crits Location: Studio	26	27	**28** AM/PM Desk Crits Location: Studio	29 DECEMBER	30	WEEK 13
WEEK 14	1	**2** FINAL STUDIO DAY AM/PM Desk Crits Location: Studio	3	4	5	6	7	
	8	**9** **PART 3 ACM** **PRINT DEADLINE**	10	**11** **PART 3 DUE** **FINAL REVIEW** **LOCATION:** **LOFT GALLERY**	12	13	14	WEEK 14

continued...

OFFICIAL BUSINESS

ARCH 393 is scheduled as follows.

Mondays:	9:30 a.m. - 12:30 p.m.	**Thursdays:**	9:30 a.m. - 12:30 p.m.
	1:30 p.m. - 5:30 p.m.		2:00 p.m. - 5:30 p.m.

PARTICIPATION

One of the principles of the studio is that everyone be involved in a critical and speculative dialogue with regard to their own work and the work of others. Students are encouraged to work in the studio throughout the term.

Students are expected to be working in the studio during the above scheduled hours and to attend and participate in all scheduled reviews and events. Participation includes the cultivation of a critical and productive studio atmosphere through active engagement and curiosity, attendance at lectures and reviews.

The work in the studio also requires a commitment to the development of new computational skills. To facilitate this, a series of workshops, lab sessions and exercises have been planned. It is expected that all students are actively engaged in these sessions.

EVALUATION

Each assignment throughout the term will be assessed on the following basis:

> Ambition, clarity and appropriateness of the ideas addressed within the work.

> Invention, innovation and vision embodied within the work.

> Criticality/integration of computational strategies in design proposals.

> Architectural/spatial quality and technical resolution of the proposition.

> The effectiveness and completeness of project documentation and the work's capacity to communicate a project's intentions in the author's absence.

> Integrity in the development of the project from initial to final phase.

> Precision and craft of physical artifacts created.

In addition to this list, a more specific set of measures will be identified in individual project handouts. Grades will be made available to students through LEARN. Faculty will do their best to publish grades in a timely manner.

GRADES

Students must complete all projects and assignments and obtain a passing average in order to receive credit for this course. Failure to earn a passing grade on the final project will result in a failing grade for the term, notwithstanding the cumulative mark from aggregate term projects.

> Course Project Part 1: 25%

> Course Project Part 2: 30%

> Course Project Part 3 (Final Project): 40%

> Workshop/Lab Exercises: 5%

Official Business continued...

DEADLINES & EXTENSIONS

Assignments that are handed in late will receive a penalty of 5% per calendar day, after 5 days, the assignment will receive a 0%. Only in the case of a justified medical or personal reason will these penalties be waived, and only if these have been officially submitted to the Undergraduate Student Services Co-Ordinator and accepted by the Undergraduate Office.

If you choose to produce digital drawings for any portion of a project's submission requirements, you must make early paper backups of your drawings – we expect that you will need to print your work regularly in order to evaluate its content. Last minute printing problems, lost or corrupt files will not be accepted as an excuse for late project submissions.

All work in this course must be presented physically regardless of your preferred working methodology.

SUBMISSIONS

Digital files are required to accompany all major project submissions - however, they must be accompanied by paper printouts or formatted physical panels unless otherwise specified. Specific lists of the requirements of each project submission will be included with individual project handouts.

Digital submissions will be required as a means to archive the work of individual students and groups throughout the term. A process for submitting work will be specified closer to project due dates.

REVIEWS

Please note that reviews are instructive and not evaluative. It is therefore important for each individual to participate in both the review of their own work, and in the reviews of the work of fellow students. Participation in Class Reviews is mandatory.

COLLABORATIVE WORK

It is recommended that students work on the course project in pairs. This collaboration should allow for intensive work and iterations to take place in parallel. Generally, the more iterations are pursued the stronger the work. If you work as a pair, you will be evaluated as a pair - so pick your partner wisely. Acknowledging that sometimes difficulties emerge, faculty will work with students to work through problems and make accommodations in group formations to support the production of high quality work as needed.

AVOIDANCE OF ACADEMIC OFFENSES

Academic integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check the Office of Academic Integrity for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. [Check the Office of Academic Integrity for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties.

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72, Student Appeals.

Note for students with disabilities: AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Turnitin.com and alternatives: Text matching software (Turnitin) will be used to screen assignments in this course. This is being done to verify that use of all material and sources in assignments is documented. In the first week of the term, details will be provided about the arrangements for the use of Turnitin and alternatives in this course.

Note: students must be given a reasonable option if they do not want to have their assignment screened by Turnitin. See Academic Integrity - Guidelines for Instructors for more information.

COMMUNICATION

LEARN, the official online course portal for the University of Waterloo, will be used as a communication and dissemination tool. Please go to http://learn.uwaterloo.ca and log in using your WatIAM/Quest userId and password. Once you are logged in to LEARN you will see a list of courses to which you have access.

You will receive general communications from the coordinator regarding studio business. It is expected that you check your email address regularly.

DIGITAL ARCHIVE SUBMISSION

The student work archive is essential for the school, not only to build a portfolio for accreditation, but also for the development of the website, print publications, and exhibitions. Student Work will be submitted via LEARN at the end of the term. Your instructor will, in turn, review and submit your materials to the digital archive.

Please read over the guidelines for the archive submission (on LEARN in the Course Documents Section) carefully as the digital archive protocols have been carefully created to streamline the collection of student work.

All students are required to submit their course work by the deadline specified. Individual student grades will not be submitted until the digital submission is completed.