UNIVERSITY OF CALGARY
SCHOOL OF ARCHITECTURE, PLANNING AND LANDSCAPE

Fall 2023

Course Number	ARCH 680.24 L04	Classroom	CBDL
Course Name	Introduction to Robotic Fabrication		
Pre/Co-Requisites			
Instructor	Guy Gardner	**Office Hours/Location**	by appointment
	Email: gegardne@ucalgary.ca	**Phone:** 403-471-0183	
Class Dates	In Person, Tuesday/Thursday 9AM -10:30AM		
Instructor Email Policy	Please note that all course communications must occur through your @ucalgary email, and I will respond to emails sent via student's @ucalgary emails within 48 hours.		
Name and Email of Teaching Assistant(s)	Arman Khalil Beigi: arman.khalilbeigikha@ucalgary.ca		

Course Description:
Thematic inquiry and design related to special topics in architecture.
Course Hours: *3 units; (3-0)*
MAY BE REPEATED FOR CREDIT

Robotic fabrication tools and processes are transforming design and construction. The Introduction to Robotic Fabrication course is intended for students and practitioners who are interested in exploring digital-physical translation and the implications of industrial robotic manufacturing for architectural design research. Collaborative design and making activities will introduce robot programming and integration in a hands-on manner. Lectures and tutorials on computational form-finding and robotic path planning will help students develop skills necessary to program, simulate and execute human/machine collaborative processes to produce novel architectural prototypes. Participants will learn the vocabulary and working practices necessary to work safely with automated fabrication equipment. Software including Rhino, Grasshopper, Robotstudio and various software plugins will be used to control Universal UR10-E and ABB IRB2600 Industrial Robots. Students will work iteratively to develop end-of-arm tooling, toolpaths, commands, I/O systems and other elements necessary for the production of a final exhibition-ready prototype. In the process, participants will also explore themes related to circularity and material upcycling, structural reciprocity, tectonics, joinery and human-machine collaboration. Assignment deliverables will include models and mock-ups, documentation, and written reflection and speculation on research opportunities.

Course Hours: 3 units

Course Learning Outcomes:
Upon completion of this course, students will be able to:

1.Program a robot using a teach pendant

2.Design a robot simulation and execute a toolpath.

3.Design a component or assembly suitable for robotic fabrication and produce necessary drawings /fabrication instructions for robotic construction

4.Produce high quality documentation and analysis of simulations, mock-ups and prototypes

5.Present the findings of their research in the form of a report and presentation.

Learning Resources:
https://academy.universal-robots.com/free-e-learning/e-series-e-learning/
- Rhino 6/Grasshopper 3d modelling software.
- Various conference publications: http://papers.cumincad.org

Technology requirements (D2L etc.):
In order to successfully engage in their learning experiences at the University of Calgary, students taking online, remote and blended courses are required to have reliable access to the following technology:

A computer with a supported operating system, as well as the latest security, and malware updates

A current and updated web browser

Webcam (built-in or external)

Microphone and speaker (built-in or external), or headset with microphone

Current antivirus and/or firewall software enabled

Broadband internet connection

Most current laptops will have a built-in webcam, speaker and microphone

Workshop Safety Training Requirement
If a course requires the use of the SAPL workshop, students must complete all online University of Calgary safety courses, the online Trajectory safety training course, as well as in-person workshop training and a grade of pass on the final evaluation project, to be granted access to the SAPL workshop. This training is offered once a year, around the start of the Fall term and has a completion deadline.

Additional Classroom Conduct and Related Information

Guidelines for Zoom Sessions in Online Classes
Students are expected to participate actively in all Zoom sessions and to turn on their webcam. Please join our class in a quiet space that will allow you to be fully present and engaged in the Zoom sessions. Students must behave in a professional manner during the session. Students,

employees, and academic staff are also expected to demonstrate behaviour in class that promotes and maintains a positive and productive learning environment

Assessment Components:

Assessments carried out during the last 14 calendar days of classes in Fall/Winter Terms and the last 7 calendar days in Spring/Summer Intersessions (as defined in the **Academic Schedule**) may not total more than 15 per cent of the final grade, except in the case of laboratory or oral testing, presentations or summative projects/papers.

c. The final exam may not count for more than 50 per cent of the final grade, except in: (1) the cases of clinical or professional practice-based courses in academic programs leading to professional designation, registration and/or licensing (2) or in situations outlined in section **G.1.2 In-Course Assessments and Absences**.

Assessment Method	Description	Weight	Aligned Course Learning Outcome	Due:
Robot basics: Animated simulation + quiz.	Demonstrate basic competency and safe working practices (individual)	20%	1,2	Oct 5
Presentation: Computational Design	PDF/Presentation/Animation: Proposal. Robotic path simulations. Drawings, Diagrams, Models + prototypes. (Partners)	30%	2,3,4,5	October 28
Human/Machine Collaborative Prototype	Exhibition-ready prototype + Project documentation (video/animation) (Teams)	40%	2,3,4,5	December 2
Written Reflection + participation	Short paper/report. Peer review document. (Individual)	10%	5	Dec 5

Assessment and Evaluation Information

Attendance and Participation Expectations:

Students are expected to follow all assignments, to be present in class on Tuesday and Thursday mornings and attend all lectures and reviews. Students are expected to read any assigned readings. Students are expected to complete all course assignments on time. There will be no final exam but a final presentation.

Guidelines for Submitting Assignments:

Students will be evaluated individually for all assignments. In the case of group assignments, participants will be asked to describe their contribution to the assignment. Projects will be evaluated for completeness, quality, and originality.

Final Examinations: N/A

Expectations for Writing (https://www.ucalgary.ca/pubs/calendar/current/e-2.html):

Late Assignments:

Assignments should be submitted to D2L Dropbox on or before the due date. Assignments submitted after the deadline will be penalized with the loss of a grade (e.g.: A- to B+). For late submission after one week but not more than 2 weeks late, the loss will be two grades, e.g.: A- to B. Assignments will not be accepted after 3 weeks.

Criteria that must be met to pass:

Students must obtain an overall passing grade to pass this course, however, if a student fails any phase of the course worth 30%, or more, they will fail the course. If a student has questions about an assignment grade, the student can discuss grades with the instructor within **fifteen days** of being notified about the mark or of the item's return to the class. More information can be found in the Graduate Calendar: http://www.ucalgary.ca/pubs/calendar/grad/current/gs-o.html

Grading Scale:

Grade	Grade Point Value	4-Point Range	Percent	Description
A+	4.00	4.00	95-100	Outstanding - evaluated by instructor
A	4.00	3.85-4.00	90-94.99	Excellent - superior performance showing comprehensive understanding of the subject matter
A-	3.70	3.50-3.84	85-89.99	Very good performance
B+	3.30	3.15-3.49	80-84.99	Good performance
B	3.00	2.85-3.14	75-79.99	Satisfactory performance
B-	2.70	2.50-2.84	70-74.99	Minimum pass for students in the Faculty of Graduate Studies
C+	2.30	2.15-2.49	65-69.99	All final grades below B- are indicative of failure at the graduate level and cannot be counted toward Faculty of Graduate Studies course requirements.
C	2.00	1.85-2.14	60-64.99	
C-	1.70	1.50-1.84	55-59.99	
D+	1.30	1.15-1.49	50-54.99	
D	1.00	0.50-1.14	45-49.99	
F	0.00	0-0.49	0-44.99	

A student who receives a "C⁺" or lower in any one course will be required to withdraw regardless of their grade point average (GPA) unless the program recommends otherwise. If the program permits the student to retake a failed course, the second grade will replace the initial grade in the calculation of the GPA, and both grades will appear on the transcript

The School of Architecture, Planning and Landscape will not permit the Flexible Grade Option (CG Grade) for any course offered by the School.
https://www.ucalgary.ca/pubs/calendar/current/f-1-3.html

CACB Student Performance Criteria (for Architecture courses only)

The following CACB Student Performance Criteria will be covered in this course at a primary level (other criteria will be covered at a secondary level): A1 Design Theories, Precedents and Methods, A2 Design Skills; A3 Design Tools, A8 Design Documentation; B1 Critical Thinking and Communication; C2 Materials.

Topic Areas & Detailed Class Schedule

Course Schedule Date	Topic	Assignments/Due Dates
Phase 1: Technique		
Tuesday, Sept 5	COMPUTATION Start of fall semester classes Lecture 1: Course + teaching team Intro Review of last year's project, overview of course and workshop proposal.	Introduce Assignment 1. Simple robotic simulation, UR Academy Certification and ABB quiz.
Thursday, September 7	FABRICATION: UR Robot introduction and overview, basic instructions, safe practices and terminology. Universal Academy overview.	
Tuesday, Sept 12	COMPUTATION: Rhino/grasshopper basics Elements of robotic fabrication: points, vectors, planes. Lists and data trees. Best practices for visual scripting. Loading plugins.	
Thursday, Sept 14	FABRICATION: Designing and executing a routine using teach pendant programming	*Last day to drop course without financial penalty
Tuesday, Sept 19	COMPUTATION. Robots plugin: Installation, loading libraries and basic workflow Digital/physical robot work-cell twins and Robot simulations: basic requirements. Mounting tools, adding commands.	
Thursday, Sept 21	FABRICATION ABB robot workshop. Understanding Different robot brands and types and overview of robot programming syntax.	
Tuesday, Sept 26	COMPUTATION	

	Lecture/ Tutorial: Simple Offline Simulation examples: extrusion and pick+Place	
Thursday, Sept 28	FABRICATION Off-line simulation. Loading a script written in grasshopper. Network communication. Remote control, reading poses and TCP locations.	
Tuesday, Oct 3	COMPUTATION: introduction to Meshes, reciprocal frames, topology graphs theory. (Nexorade structure + additional case studies)	
Thursday, Oct 5	In-class quiz + work period	Assignment 1 Due: Collision and error-free simulation animation. + Universal/ABB robotic fabrication basics quiz.
Monday, October 9th	Thanksgiving Holiday	
Phase 2: Material Tests		
Tuesday, Oct 10	COMPUTATION RobotsGH: Extended functionality. Programming + simulating commands + I/O	Introduce Assignment 2
Thursday, Oct 12	FABRICATION Integrating commands + I/O. Grippers, extruders, Range extenders , Work cell coordination, human/machine collaboration.	
Tuesday Oct 17	COMPUTATION Labels + Tags, Unrolling, Nesting+ Preparing fabrication files	
Thursday, Oct 19	FABRICATION AR tools for localization and visualization: fologram plugin for rhino/GH + mobile App	
Thursday, Oct 24	COMPUTATION: Production of prototypes + mockups documentation, testing, lit review.	
Thurs Oct 26	FABRICATION Production of prototypes + mockups documentation, testing	
Tuesday, Oct 31	Student Presentations, Assignment 2	Assignment 2 Due: PDF + short animation + in-class presentation: Robotically Fabricated Structure Proposal. Robotic path simulations. Drawings, Diagrams, Models + prototypes.
Thursday, Nov 2	Student presentations Assignment 2	Introduce Assignment 3
Phase 3: Assemblies		
Nov 6-10	No classes – Block Week	
Nov 12-18	Fall Term Break, no classes	
Tuesday, Nov 21	Production	
Thursday, Nov 23	Production	
Tuesday, Nov 28	Production	

Thursday, Nov 30	Production	
Tuesday, Dec 7	Last day of class: Final project reveal. Post-mortem decompression + reflection	Assignment 3 and 4 Due: Exhibition-ready prototype + Project documentation (video/animation) (Teams) Short paper/report. Peer review document. (Individual)
Dec 6	End of fall semester classes	** Last day to withdraw form a course

University of Calgary Policies and Supports

It is the student's responsibility to request academic accommodations according to the University policies and procedures listed below. The student accommodation policy can be found at: https://www.ucalgary.ca/legal-services/university-policies-procedures/student-accommodation-policy

Students needing an accommodation because of a disability or medical condition should communicate this need to Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities:https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Accommodation-for-Students-with-Disabilities-Procedure.pdf. Students needing an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, preferably in writing, to their instructor (contact information on first page above).

SAS will process the request and issue letters of accommodation to instructors. For additional information on support services and accommodations for students with disabilities, visit www.ucalgary.ca/access/ .

ACADEMIC MISCONDUCT

Academic Misconduct refers to student behavior which compromises proper assessment of a student's academic activities and includes: cheating; fabrication; falsification; plagiarism; unauthorized assistance; failure to comply with an instructor's expectations regarding conduct required of students completing academic assessments in their courses; and failure to comply with exam regulations applied by the Registrar.

For information on the Student Academic Misconduct Policy and Procedure please visit: https://www.ucalgary.ca/legal-services/university-policies-procedures/student-academic-misconduct-policy
Additional information is available on the Academic Integrity Website at https://ucalgary.ca/student-services/student-success/learning/academic-integrity.

COPYRIGHT LEGISLATION:

All students are required to read the University of Calgary policy on Acceptable Use of Material Protected by Copyright (https://www.ucalgary.ca/legal-services/university-policies-procedures/acceptable-use-material-protected-copyright-policy) and requirements of the copyright act (https://laws-lois.justice.gc.ca/eng/acts/C-42/index.html) to ensure they are aware of the consequences of unauthorised sharing of course materials (including instructor notes, electronic versions of textbooks etc.). Students who use material protected by copyright in violation of this policy may be disciplined under the Non-Academic Misconduct Policy (https://www.ucalgary.ca/pubs/calendar/current/k.html).

INSTRUCTOR INTELLECTUAL PROPERTY

Course materials created by instructors (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the instructor. These materials may NOT be reproduced, redistributed or copied without the explicit consent of the instructor. The posting of course materials to third party websites such as note-sharing sites without permission is prohibited. Sharing of extracts of these course materials with other students enrolled in the course at the same time may be allowed under fair dealing.

FREEDOM OF INFORMATION AND PROTECTION OF PRIVACY

Student information will be collected in accordance with typical (or usual) classroom practice. Students' assignments will be accessible only by the authorized course faculty. Private information related to the individual student is treated with the utmost regard by the faculty at the University of Calgary.

SEXUAL AND GENDER-BASED VIOLENCE POLICY

The University recognizes that all members of the University Community should be able to learn, work, teach and live in an environment where they are free from harassment, discrimination, and violence. The University of Calgary's sexual violence policy guides us in how we respond to incidents of sexual violence, including supports available to those who have experienced or witnessed sexual violence, or those who are alleged to have committed sexual violence. It provides clear response procedures and timelines, defines complex concepts, and addresses incidents that occur off-campus in certain circumstances. Please see the policy available at https://www.ucalgary.ca/legal-services/university-policies-procedures/sexual-and-gender-based-violence-policy .

UNIVERSITY STUDENT APPEALS OFFICE

If a student has a concern about a grade that they have received, they should refer to Section I of the Undergraduate Calendar (https://www.ucalgary.ca/pubs/calendar/current/i-3.html) which describes how to have a grade reappraised. In addition, the student should refer to the SAPL's Procedure for reappraisal of grades

OTHER IMPORTANT INFORMATION

Please visit the Registrar's website at: https://www.ucalgary.ca/registrar/registration/course-outlines for additional important information on the following:

- Wellness and Mental Health Resources
- Student Success
- Student Ombuds Office
- Student Union (SU) Information
- Graduate Students' Association (GSA) Information
- Emergency Evacuation/Assembly Points
- Safewalk