ROB|FAB

MATERIAL AFFORDANCE IN DIGITAL DESIGN

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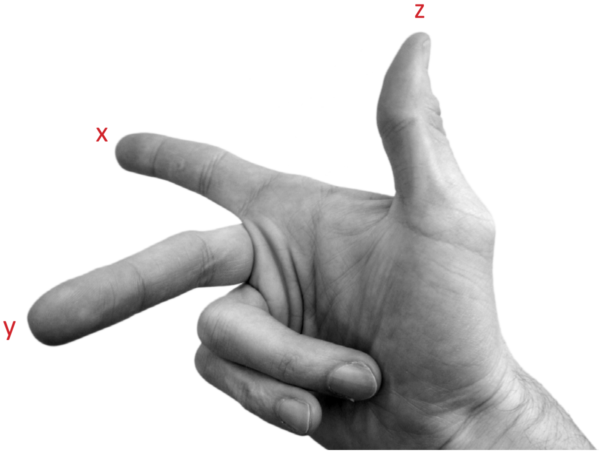
Tuesday 9^00^ -11^50^
dFab, MM C4

Rob|Fab is an introductory seminar to robotic fabrication in architectural design. Architectural robotics is a rapidly emerging field where precise motion control, custom tooling, and advanced digital protocols intersect with the shaping of the built environment. While there are many novel possibilities afforded by new robotic tools, we do best to remember that human hands have been creatively shaping matter throughout history and that the collective knowledge gained during this process should be at the forefront of advancing digital fabrication and contemporary design.
With this in mind, *Rob|Fab* requires students to get their hands dirty. Material testing, physical prototypes, and failed experiments will leverage a robot's unique capacity to explore the relationship between atoms and bits in built form.

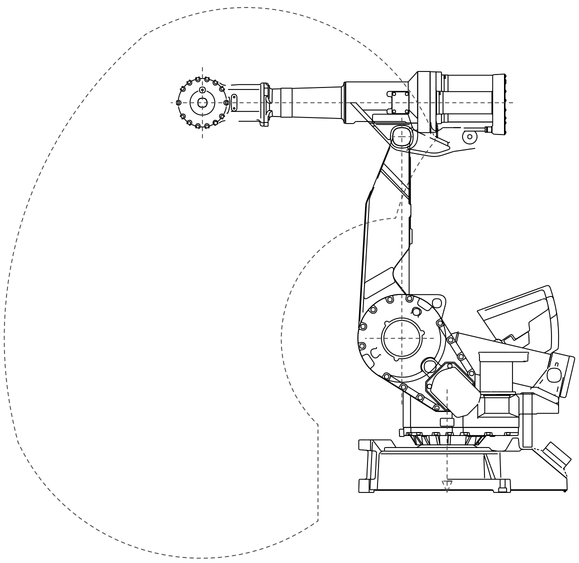
Objectives core competencies

- to understand the fundamentals of robot motion control.
- to apply basic robotic programming to real world machining applications.
- to negotiate the translation from digital models / drawings to machined components and assemblies.
- to control issues of tolerance, finish, and detailing through precise tooling.
- to experience the work of the practiced hand in relation to digital machines.
- to develop a general framework as designers for understanding computer aided manufacturing.

Outline The course will begin with a series of introductory exercises aimed to introduce students to fundamental topics of robot motion control, tool definition, material fixturing, and work cell setup. Following these preliminary exercises, students will conduct material experiments that link custom tooling, robotic motion, and material behavior. Based on the results of these tests students will produce a final project, which synthesizes the work toward an innovative architectural application.



Lab Procedures Students will be expected to understand and follow all procedures outlined by the dFab handbook. Students are expected to keep staging and work areas clean and well ordered since we will be sharing lab space with others throughout the semester. Students are also expected to schedule machine time with trained



lab monitors where appropriate; please plan ahead and respect the lab's schedule.

Safety All students must follow the basic safety procedures posted in the dFab Lab. In particular the use of safety glasses, ear protection, and closed toed shoes are required when engaging in fabrication activities. In addition students should use caution when operating robotic equipment. Understand and stay clear of the robots work envelope when running programs. Make sure work pieces are securely positioned before machining. Never operate the robot without at least one other person present. When in doubt ask for help.

Documentation Students are required to carefully document the product and process of all projects through considered drawings, images, physical prototypes, and digital models. Since the course encourages speculative thinking through making, students are encouraged to document failed attempts, detours, and hunches that haven't quite been worked out in the spirit of creatively engaging the tools and materials at hand. A complete set of documentation should be uploaded to blackboard at the close of each project (template forthcoming).

Resources

Hardware

ABB IRB–4400
External Rotary Axis with Vacuum
4'x4' Work Table with Vacuum
We will primarily use the dFab Lab's in-house ABB robot work cell for all coursework. Students are encouraged to use the Lab's additional equipment for fabrication of end of arm tooling and positioning fixtures.

Software

Translating from digital geometry to usable robot code often requires a constellation of software platforms. Vital to this process is the ability to digitally simulate all operations before running files to avoid collisions, singularities, or unforeseen positioning. Some potential work-flows:
Rhino > Robot Master > Robot Studio
Rhino > SuperMatter Tools (Python)
Rhino > HAL (Grasshopper)

Documentation / tutorials

Pertinent Documentation for ABB Rapid code, Robot Studio, SuperMatter Tools, Grasshopper and HAL will be filed under Resources on blackboard. You can also go directly to the source:
ABB | SMT | HAL | dFab

Materials While machine time associated with this course will be free, students will be expected to provide necessary materials for all projects. Group work throughout the semester is intended to mitigate the overall cost per student but please plan your budget this term accordingly. Where possible the instructor will offset the cost of materials for the group.

Grading Criteria

- Attendance at and active participation in class sessions.
- Conducting focused and ambitious material research
- Exhibiting proficiency in Robotic equipment / software covered in this course
- Careful documentation of projects Attention to the details of craft

A excellent Work reflects outstanding achievement in content and execution. Work far exceeds given requirements. Students in this category demonstrate: High self motivation, Independent thinking and expression, Highly disciplined, Willingness to take risks, High ability to focus, Systemic questioning, Self critique and editing, Highest qualities of representation

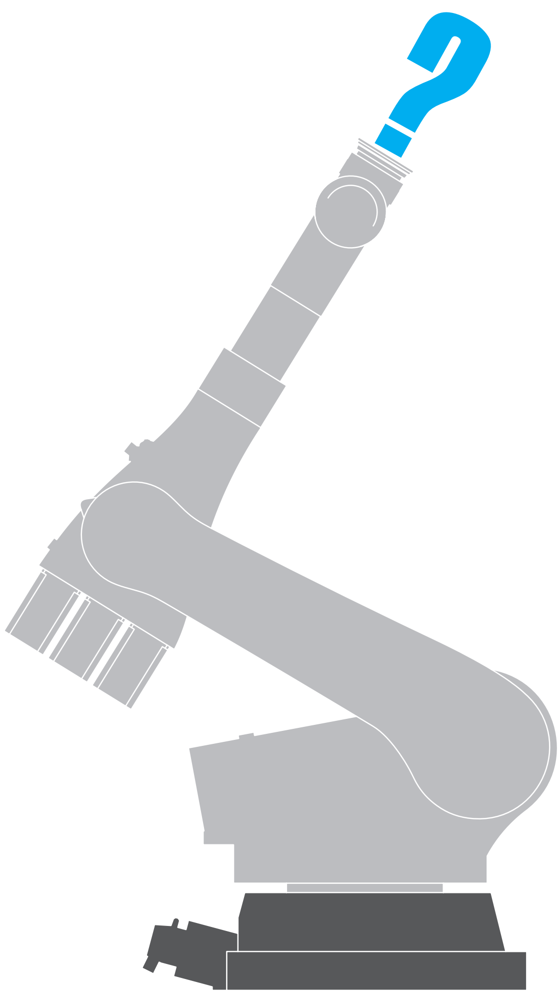
B good Work reflects high achievement in content and execution. Work exceeds given requirements. Students in this category demonstrate: Some external motivation, Periodic independent thinking, Good discipline, Beginning to take risks, Good qualities of representation, Periods of focus, Closed-ended questioning, Open to suggested critique and editing

C satisfactory Work fulfills given requirements. Students in this category demonstrate: External motivation, Dependent on precedent, Low discipline, Conformity, Short periods of focus, Average qualities of representation, Limited questioning, Dependent on external critique and editing

D poor Work is less than satisfactory. Work minimally or incompletely fulfills given requirements. Students in this category demonstrate:
Lacking motivation, Dependent on precedent, Lacking discipline, Duplication, Few periods of focus, Low qualities of representation, Little questioning, Non-responsive to external critique and editing

R inadequate Work fulfills few or none of the given requirements.

I incomplete Given only for emergency or medical reasons.



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Schedule

Robo|Camp	01	01.15	Introduction	HAL	1.1 released
	02	01.22	Workshops (as Needed)	Robot Studio	
	03	01.29	Working		
	04	02.05	No Class	[en]Coding Architecture	1.1 Due
Material Testing	05	02.12	Review 1.1	Super Matter Tools (SMT)	2.1-2 Released
	06	02.19	Research Review		2.1 Due
	07	02.26			
	08	03.05	Working	Wire Saw Online???	
	09	03.12	Spring Break		
	10	03.19	Review 2.1-2		2.2 Due
Project	11	03.26			3.1-2 Released
	12	04.02	Working		
	13	04.09	Mid-Review		3.1 Due
	14	04.16	Working		
	15	04.23	JDB in Boston		
	16	04.30	Final Review 3.1-2		3.2 Due

*Note: schedule subject to change

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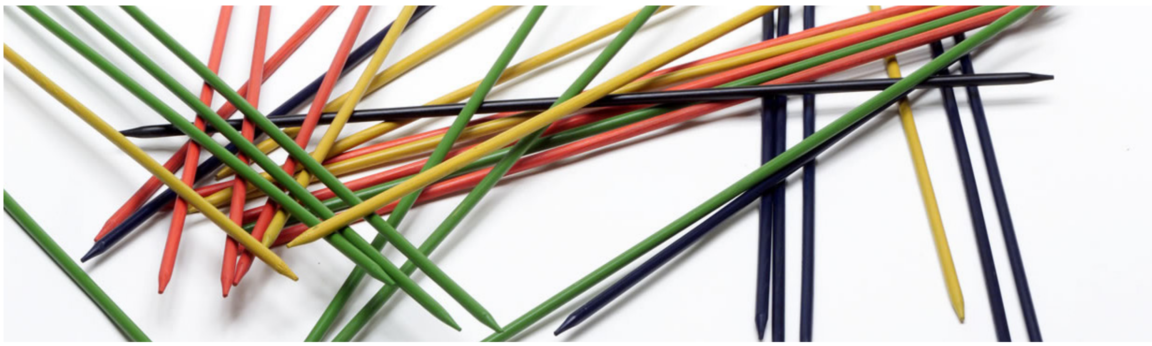
Sticks Project 1.1



Pick and place applications have long been a standard for industrial robotic manufacturing and constitute one of the most basic categories of robotic control. *Sticks* asks you to imagine material handling at an architectural scale. In particular, Project 1.1 investigates the tectonic potential of architectural framing systems relative to complex material arrays. What structural and spatial possibilities are generated by precisely locating framing members in three dimensions?

Design Problem Build an array of 50 (+/-) sticks, which spans a distance of 36 inches. All sticks must be placed using a custom robotic end effector.

Key Skills students should learn to...
Create custom tools for robotic applications
Define work objects within a work cell
Precisely index materials in multiple positions
Program basic robotic motion

Custom Tools

This project requires you to design and fabricate a custom end effector to pick up and locate your series of sticks. Your tool should attach to the lab's ATI tool plates. The project also entails indexing your material with a custom fixture such that the robot knows where to find each piece.

Workflow (the following should not necessarily be taken as linear)

- Acquire 50 identical sticks (roughly 3/16" in diameter and 9"–12" long).
- Construct a custom tool which allows the robot to precisely place individual sticks.
- Develop a digital model to virtually array the sticks (parametric control will be key here so Grasshopper or Python might prove useful.
- Produce the necessary target geometry to enable the robot to assemble your array.
- Physically construct at least one full array with smaller prototypes to support the investigation.
- Ask questions of the process: How does the robot pick up and release each stick? How are the sticks held together? How do you support the first few sticks?

Deliverables

Models: complete and test models
Documentation: Project 1.1 is intended to promote open inquiry within the constraints of a simple design problem. Students should energetically test possibilities through physical models and considered representation. Document this process carefully using photographs, video, drawings and diagrams.

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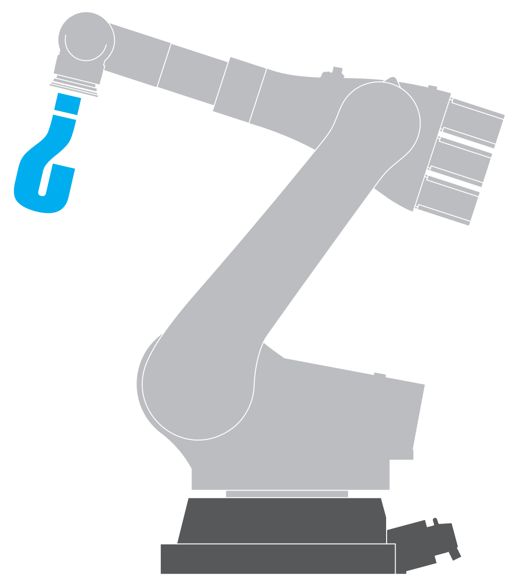
Material Research

Project 2.1



Material Research asks you to develop a defined area of research that can be explored through physical prototyping and iterative testing. This project will ask you to apply the basic techniques of robot motion control, tool creation, and work cell definition from Project 1.1 toward speculative material experimentation. We will continue to work in groups (you are welcome to choose new partners). Each group should consider one of the projects listed below.

Timber Framing Couple the logic of *Sticks* Project 1.1 with the potential of robotic wood joinery to produce complex timber frames. This project would require working with wood joinery at 1:1 while continuing to explore precise material placement at model scale.

Material Arrays Directly extend the work of *Sticks* Project 1.1 and continue to explore complex material arrays. This project would require increased dexterity in spatial complexity and suggest a secondary mode of inquiry (e.g. complex form finding or computer vision)

Perforated Metal Deformation Explore robotic plasma cut perforation patterns in sheet metal which are deformed with the lab's IRB 4400 to create volumetric distortions. This project would require use of the metal shops IRB 1600 plasma cutting setup.

Wood Bending Use the robot to precisely manipulate steam bent hardwood. This project would require working with the historic technique of steam bending to explore forms not possible by traditional hand techniques.

Architectural Plaster Explore robotic techniques for applying architectural plaster. This project would require building custom profiling tools which would require an additional external axis. This group would work closely with a team of students from the Robotics Institute to implement and control custom tools.

Original Project Propose an original project which investigates the innovative use of robots to shape the built environment. Proposed projects should locate a primary material and understand the operations necessary to shape that material at an architectural scale.

Key Dates

02.26 > Initial conversation with groups about project choice.
03.05 > Groups present 10 min presentation regarding proposed project along with a one page project proposal.