CourseNo: ARCHA4141_001_2015_1
Meeting Time: R 07:00P-09:00P **Meeting Location:** BUELL HALL 200

Instructor Information:
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View Course Presentation here:
https://courseworks.columbia.edu/access/content/group/ARCHA4141_001_2014_1/Beyond%20Prototype_Spring_2014.pdf

Course Overview and Objectives:

The relationship between the components of structure and the components of enclosure is conventionally considered to be mutually exclusive. However, in an environment where material efficiency and speed of fabrication is becoming more important, there exists an opportunity for the architect to intervene within the fabrication process to assimilate both structure and envelope into one hybridized system that abolishes exclusivity and attains a higher level of efficiency. This course will encourage and enable students to use digital software as a generative tool and the laser cutter, CNC Mill, plastic bender and welder as a means to bring virtual systems into the physical realm. Emphasis will be placed on using the digital fabrication machines to extract forms from conventional, flat sheet stock that can be transformed using cutting, bending and folded manipulation in order to create a topological network of elements: a homogenous, self supporting mesh. Structural elements will be formed from a sheet material which in raw form is not stable as a stand alone building component. We will create structure from non structure and complex systems from simple surfaces. Special emphasis will be placed on the development of connection details and their incorporation into the overall language of the network. In this way the students will be able to explore and design a complex, homogenous network or mesh of a single material that performs efficiently as both structure and enclosure. We will study the complexities of transforming non uniform NURBS geometry with superimposed surface tessellation, into a three dimensional network. This generative process will be employed as a strategy for developing new architectural component systems. Specific emphasis will be placed on the use of multiple systems of geometry within the same structural network in order to discern elements of surface and elements of connection.

Rhino will be used as a primary generative software platform during the design and fabrication process. Instruction will then focus on using Grasshopper to streamline the generation and parametric manipulation of complex cellular networks and surface tessellations. Students will be operating across multiple platforms to devise a completely automated design and fabrication process.

The research objectives of this course encourage students to devise functional design applications, establish contextual relevance for their component systems and propose realistic fabrication scenarios based on quantifiable material and mechanical constraints. Components are extracted from the digital realm, built at full scale, tested and reevaluated, effectively taking us beyond prototype. Project development and presentation / fabrication requirements of this course will allow design teams to easily submit their proposals to various fabrication focused competitions such as TEX-FAB..

Lecture/Tutorial Schedule:

Week 1: Form Generation: Case Studies in Surface Generation and Component Systems / Periodic Surfaces / Layered Meshes / Rhino Surface & Tessellation Modeling / UV Division

Week 2: Parametric Network Creation: Joinery Techniques / Connective Geometry / Component based Grasshopper Modeling / Flattening / Unfolding
Week 3: Material Simulation: Solid Works Modeling and Element Analysis
Week 4: Automated Fabrication: Drawing for the Machine/ using Grasshopper and Rhino tools for unrolling 3D Geometry and Machine File Preparation/ Tool Pathing/ Hardware Selection and Modeling
Week 5: Fabrication Techniques: Metal Fabrication / CNC Milling / Plastic Bending / Adjustable Jigs/ Welding / Finishing/ Thermoforming Plastic
Week 6: Presentation & Fabrication Methods: Prototyping / Drawing for the Fabricator / Component Assembly Diagrams/ Photorealistic Rendering Techniques/ Full Scale Fabrication and Physical Assembly Process

Project Requirements:

While enrolled in this course, students will study the patterning and rhythm of non uniform NURBS geometry with superimposed surface tessellation. Teams of three or four students will then create their own complex surface or tessellation using digital modeling software and parametrically manipulate the tessellation based upon a developed set of performative criteria. The final project will involve the creation of a rigid mesh of at least 15 cells that is extracted from the original surface. Each team will be required to propose a practical application for this surface/cellular network which will help drive its form, such as a pavilion design, shell system or building façade. During the generative process, each team will perform a finite element analysis in Solid Works to analyze structural deficiencies within the overall form. This procedure will illustrate where cellular variation will be needed to make the system structurally sound or where individual components can be removed for greater material efficiency and porosity.

The overall form and tessellation strategy will be analyzed and the underlying organizational grid extracted. Students will then transform this surface grid into a three dimensional component assembly, where individual units can be formed from folding/bending sheets of plastic and metal to a create a rigid mesh or network of cells. Rhino will be used as a digital platform for generating non uniform surface geometry and complex tessellations. Students will then use Grasshopper to create a parametric cellular component system which can be applied to the surface geometry, thereby creating a building structure and envelope that is easily manipulated. Through the use of Grasshopper each group will devise a completely automated process of design and fabrication.

Students will then use the laser cutter, CNC Mill, welder and plastic bender to extract the system from the virtual realm and produce a full scale, physical counterpart which demonstrates the characteristics of the mesh system. Each team will choose a significant formal or structural moment within the cellular mesh and use the laser cutter to fabricate a small scale prototype of at least 4 cells of the network. After studying the prototypical model and calibrating the fabrication process, each group will construct 3 or 4 units of the mesh at full scale (total size 3'x3') that physically demonstrate the underlying design principles of the system including the connective geometry between units, fabrication technique (folding or bending strategy) and structural integrity. Course instruction will also include the creation of assembly diagrams for fabrication and rendering techniques for presentation of the overall vision. All processes covered in this course have been developed and calibrated to streamline the design and fabrication process, effectively enabling each student group to easily progress from design concept to full scale fabrication in just six weeks.