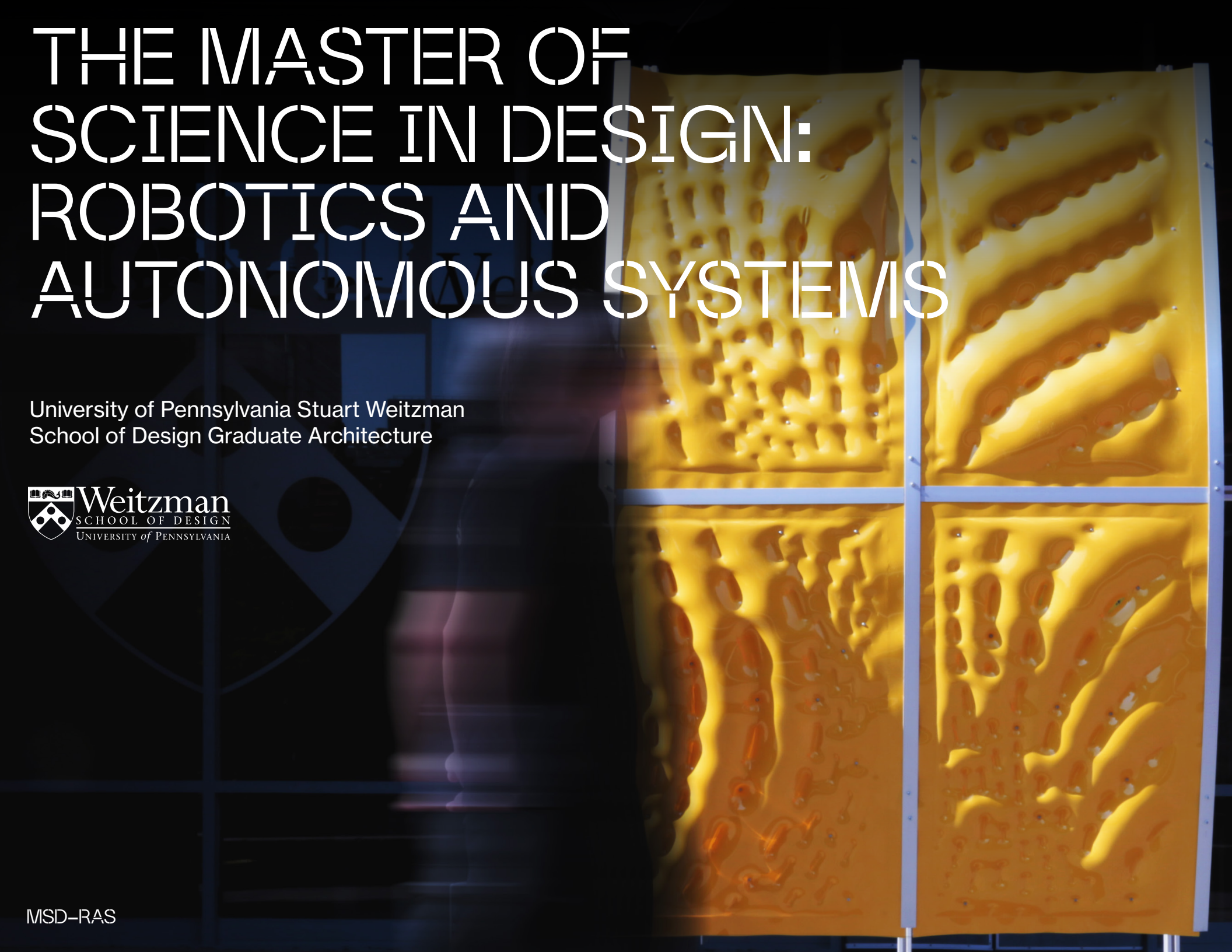
THE MASTER OF SCIENCE IN DESIGN: ROBOTICS AND AUTONOMOUS SYSTEMS



University of Pennsylvania Stuart Weitzman
School of Design Graduate Architecture

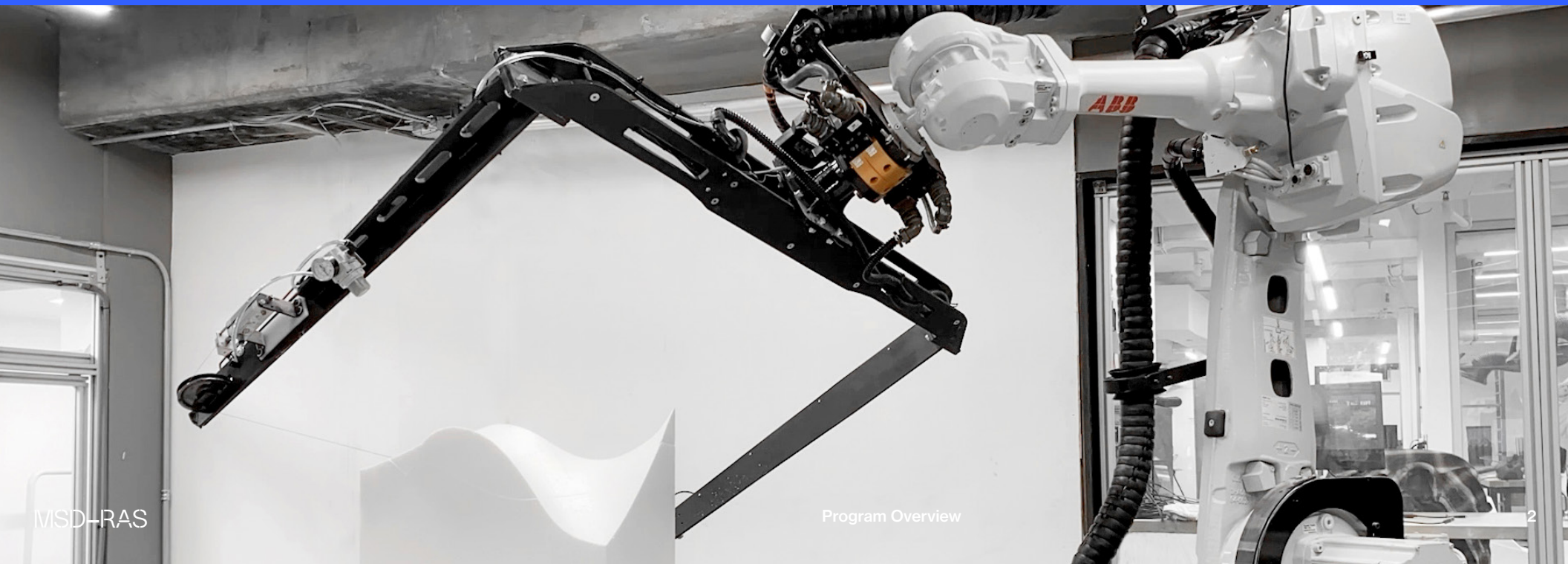
Weitzman
SCHOOL OF DESIGN
University of Pennsylvania

MSD–RAS

READY TO TAKE ON NEW CHALLENGES AND BREAK INTO EXCITING, CUTTING-EDGE FIELDS?

Transform your career by positioning yourself at the forefront of innovation in robotics, fabrication, and design-computation.

Join our one-year Master of Science in Design: Robotics and Autonomous Systems (MSD-RAS) program at the University of Pennsylvania Stuart Weitzman School of Design, and obtain a post-professional STEM degree exploring architectural design through AI and robotic fabrication.



PROGRAM OVERVIEW

The MSD-RAS aims to develop novel approaches to the design, manufacture, use, and life-cycle of architecture through creative engagement with robotics, material systems, and design- computation.

Students will gain skills in advanced forms of robotic fabrication, simulation, and artificial intelligence, in order to develop methods for design that harness production or live adaption as a creative opportunity. During the program, robotically manufactured architectural prototypes (part or whole) are developed by students and presented and exhibited at the completion of three design courses.

WHO IS MSD–RAS FOR?

- Students who already hold a first professional degree from an accredited design program in architecture.

- Post-graduate students or those who have completed equivalent programs of study in related professional fields who can demonstrate their ability to complete the required course of study.

- Professionals who have worked for several years and are seeking advanced study and credentials in robotic fabrication and artificial intellgience (AI) computational approaches to design and production.

PROGRAM GOALS

The MSD-RAS program will enable graduates to:.

GAIN state of the art robotics, AI, material fabrication, and design–computation qualifications.

DEVELOP skills in advanced methods of fabrication, computation, robot programming and multi–modal sensing technologies, and their integration within innovative design methods.

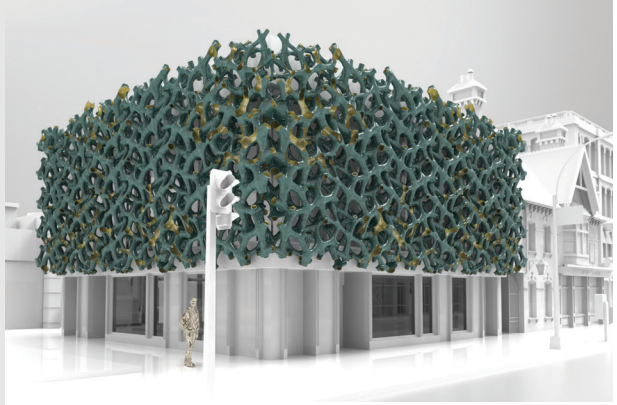
EXPAND career opportunities and options to work in ambitious and diverse fields.

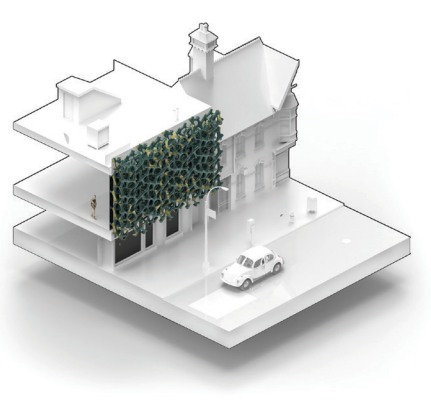
IMPACT the present and future trajectory of architecture through novel forms of production, practice and entrepreneurship.

OPERATE at the forefront of industry research and development

WHY ROBOTICS IN ARCHITECTURE?

The fourth industrial revolution (Industry 4.0) describes a recent shift towards autonomous systems, and societal reliance on cyber-physical processes that incorporate digital communications and navigation infrastructure, robotic manufacturing, and artificial intelligence. The building industry is currently undergoing transformation through the adoption of robotics technologies such as additive manufacturing systems that enable a reduction in the time, cost and complexity of delivering buildings, that also have potential humanitarian and socio-economic benefits. Adoption of these technologies also enables greater automation not only in production but also in design, challenging existing modes of architectural practice. The MSD-RAS program explores avenues for re-situating the role of architectural design within present day autonomous technologies, with the aim of expanding societal and creative design opportunities by leveraging robotic and material processes within design.





FOSTERING INNOVATIVE CAREER TRAJECTORIES

The MSD-RAS program aims to empower graduates to operate at the forefront of industry research and development, by gaining state of the art robotics, AI, material fabrication, and design-computation qualifications, and to graduate as highly skilled professionals, capable of impacting the present and future trajectory of architecture and industry through novel forms of production, practice and entrepreneurship.

Whether you're looking to advance your career, transition to new industries, start your own company, or pioneer an emerging field, the MSD-RAS program offers hands-on experience with ground-breaking technology and world-class qualifications to help you achieve your goals.

CURRICULUM OVERVIEW

The MSD-RAS program includes the following courses:

SUMMER

Introduction to 3D Programming & Machine Learning (2 week course prior to start of Fall Semester)

FALL

ARCH 801 Material Agencies: Robotics & Design Lab I (2 CU)
ARCH 803 Algorithmic Design & Robotic Fabrication (0.5 CU)
ARCH 805 Introduction to Cyber-Physical Systems (0.5 CU)
ARCH 807 RAS Theory (1 CU)
Designated Elective (Within Architecture + Engineering)

SPRING

ARCH 802 Material Agencies: Robotics & Design Lab II (2 CU)
ARCH 804 Advanced RAS Programming (1 CU)
ARCH 806 Experimental Tooling (1 CU)
ARCH 808 Scientific Research and Writing (1 CU)

Total Course Units: 10

COURSE DESCRIPTIONS

Introduction to 3D Programming

Contemporary Architectural Design has been radically redefined in the last couple of decades through a series of advances in algorithmic design, robotic fabrication and deep learning (AI). Computation, digital media, and fabrication have shifted fundamental methods of conception, drawing, modeling and construction in architecture. Algorithmic tools are often at the intersection of different disciplines allowing for novel domains of interdisciplinary research. This course provides a foundation for computational design with both generative and procedural (parametric) approaches to 3D design being explored in addition to a basic introduction to robot programming and machine learning. In addition to live-instruction an assignment is undertaken during the course that helps learned knowledge to become tacit knowledge. The specifics of the assignment and tutorials varies per year as do learning objectives. In principle, however, participants develop an introductory understanding of computational goemetry, generative design, and robot programming.

ARCH 801 Material Agencies: Robotics & Design Lab I

The Fall Material Agencies course consists of two half-semester design-fabrication sections, supported by two aligned Core Technical Seminars of half-semester length each. Students will typically work in pairs. Design discourse and subject matter for these sections varies, but is intimately related to a robotic fabrication research such as:

- Example Section: Sculptured Matter investigates the sculptural and manufacturing possibilities of robot hot-wire cutting. An extension of mathematical and artist driven surface production will be explored that leverages robot motion and geometry in order to produce exemplary robotically fabricated works.

- Example Section: Manipulative Matter explores robot manipulation-based manufacture (Eg. Sheet-metal folding) of prototypical building/sculptural parts. Sheet-metal folding requires computational modelling for geometric and fabrication rationalization in order to ensure designs can be realized by manipulating sheet material without it tearing.

- Example Section: Woven Matter aims to unify design and production within one creative process. The course commences with the development of novel programs to control the motion of Penn's industrial robots for robotic weaving. 3D design models will be developed in parallel to fabrication experiments and digital simulations.

ARCH 805 Introduction to Cyber-Physical Systems

Supports ARCH 801 Material Agencies I. This introductory seminar covers the design and assembly of electronic circuits using sensors/actuators and micro-controllers, and their use in closed or open reactive systems. The seminar work is intended to support an Arch801 project prototype to drive additional design affects (Eg. morphology/ kinetics, lighting, porosity, translucency, etc). The course explores control, feedback, energy and force in relation to interactions of matter, space and perceived activity (human or non-human), and the embedment of Internet of Things (IOT) technologies to drive additional design agencies.

"There is ample room for experimentation is this growing field, and numerous interdisciplinary career trajectories to pursue in high-value industries, where designers can operate as entrepreneurs and specialists, providing substantial societal and environmental impact".

—Robert Stuart-Smith, MSD-RAS Director

ARCH 803 Algorithmic Design & Robotic Fabrication

Supports ARCH 801 Material Agencies I. Topics vary to suit application within the Arch 801 brief. This seminar ties the programming of robot motion to a generative design process, removing conceptual and practical barriers between design conception and project implementation. Computer and robot programming skills will be developed to support both design and robotic fabrication constraints in parallel. Working within a 3d programming environment, participants will aim to program robot production methods that in turn generate design outcomes when deployed in physical processes on Penn's Industrial Robots. Subject matter and software varies, examples include: Java, Python, Grasshopper, etc.

ARCH 807 RAS Theory

This seminar provides a theoretical context to the program, relating autonomous robotics and fabrication research to architectural discourse, philosophy, science and technology. This course critically assesses present and future societal trajectories in relation to technology, exploring socio-political, ethical and philosophical arguments that concern a broader technological shift that has occurred during the last decade which has given rise to our unquestioned reliance on algorithms within our everyday lives
(social media, shopping, navigation), and similar impact from Urban OS's, Industry 4 and driverless car technologies. A theoretical written statement related to ARCH 801 Material Agencies I Section 1 or 2 will be produced by participants within this core seminar.

Designated Elective

Students may enroll in available designated electives within the schools of Architecture and Engineering.simulations.

ARCH 802 Material Agencies: Robotics & Design Lab II

The Spring Material Agencies semester-long design course demands a critical and creative response to the role of design within the domain of autonomous manufacturing and Industry 4.0. While the subject matter varies, the course centers on the demonstration of a robotically manufactured prototype that operates as a full-scale part or whole of a design proposal for a building, space, or event. Working in small groups, participants will develop designs for a speculative project-driven scenario explored within computer simulations and other forms of design media in addition to a fabricated prototype. Projects are demonstrated through a comprehensive design-research into material and robotic processes that is supported by ARCH804, ARCH806 and ARCH808 coursework.

ARCH 804 Advanced RAS Programming

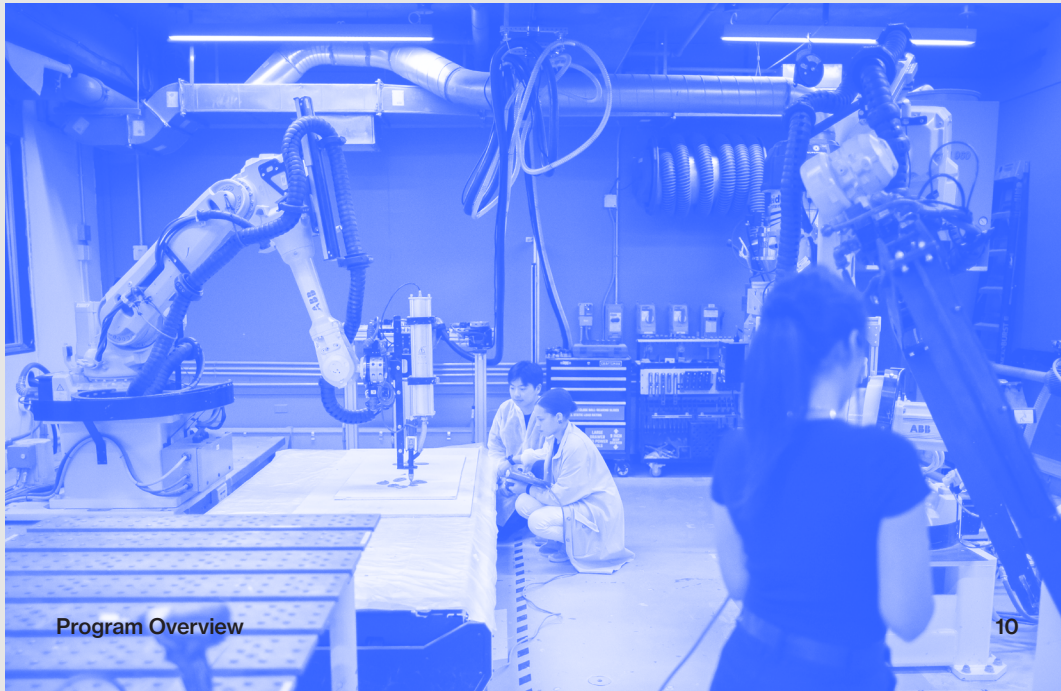
II with more advanced robot programming and decision-making methods, enabling student's greater degrees of adaptive control in their engagement with design and production processes. While
topics may appear aligned with science and engineering subjects, Arch804 does not engage in development of technologies, rather their strategic application within design, fabrication or end-use scenarios. Topics vary to suit the Arch802 design brief and emerging technologies within industry and academia. Examples include use of machine vision, machine learning, or behavior-based live-adaptation.

ARCH 806 Experimental Tooling

Experimental Tooling positions material systems as a vehicle for exploring applied research methodologies and investigations into the opportunities (and challenges) afforded by robotic fabrication techniques. More specifically, Experimental Tooling builds knowledge in robotic and material methods of production and develops applied research for industrial robot end-of-arm tooling and I/O to enhance a material production process and facilitate new design opportunities.

ARCH 808 Scientific Research & Writing

This course aims to provide students with knowledge in state-of-the-art robotics and design taking place in the research community and to introduce methods to evaluate and demonstrate academic research that encompasses both creative and technical work. Submissions will include literature review of precedent research and a technical written statement related to ARCH 802,804,806 work. The course
will help raise the level of technical and research discourse within the MSD-RAS and train students in a necessary skill required for many potential academic and industry career opportunities.



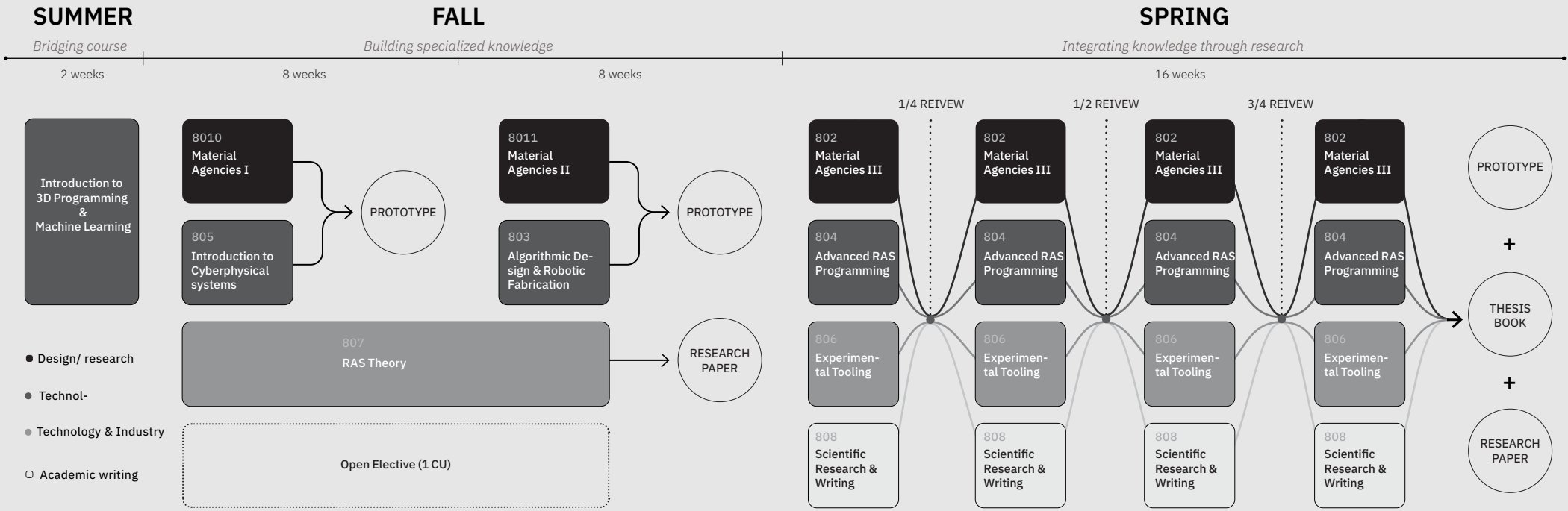
AN INNOVATIVE PROGRAM — WHAT MAKES THE MSD–RAS UNIQUE?

Located in the Stuart Weitzman School of Design – a global leader in architectural design, the MSD-RAS offers a unique education in architectural design and robotic fabrication. The MSD-RAS program offers opportunities for hands-on experimentation, design speculation, team-based collaboration, and access to world-leading facilities, with learning supported primarily through project-based work rather than through a written thesis alone.

The program's emphasis on project-based work provides practical learning opportunities, also supported by technical and theoretical courses that run in parallel and are directly related to design projects, ensuring participants learn how to approach design from multiple creative and technical aspects holistically, while learning how to communicate design-research to industry and academia. As the MSD-RAS operates within the context of a large, Ivy League, research institution, there are also overlapping interests with the departments of mechanical engineering, computation science, material science, biology, and medicine that enable opportunities for interdisciplinary collaboration, or participation in seminal interdisciplinary research and symposia.

The MSD-RAS operates from state-of-the-art facilities, such as the Weitzman School ARI Robotics Lab, and has close ties to the building industry. The program's STEM status, renowned faculty, and proximity to prospective employers in Philadelphia and New York City also ensure it offers the best industry and employment opportunities for graduates. Graduates have pursued several different career trajectories ranging from working with world-leading companies in architectural practice, fabrication, construction and volumetric design-build companies, to tech start-ups. Many graduates also go on to PhD or lecturer positions in academia.

AN INNOVATIVE PROGRAM
— WHAT MAKES THE MSD–RAS UNIQUE?



Hyper-Integrated Curricula

The two-semester-long MSD-RAS program includes three design studios that primarily operate through the development of experimental, fabricated prototypes. Each studio explores a different material and fabrication approach that varies over time. Studios' design briefs are also light on professional degree architectural criteria (such as planning, site, etc.), allowing courses to focus on core knowledge domains aligned with the program's specialization in robotic fabrication and computational design.

The first two half-semester-length studios in the fall semester are tightly choreographed in design and manufacturing workflows, operating as design workshops that expose students to a diversity of design, computation, and manufacturing methods. Each is also paired with a concurrent half-semester-long technology course whose assignments support the design studio project and culminate in augmentations to the studio's final fabricated prototype or the design and fabrication workflow. A semester-long RAS theory course and an open elective also run through the fall semester

In the final spring semester-long studio, a deeply integrated approach to curricula is explored. A research-led design thesis project is undertaken across four courses concurrently, including scientific research and writing, industrial robotics and tooling, advanced robot programming, and a design course that emphasizes research-led experimentation and the production of robotically fabricated physical prototypes. Given the MSD-RAS program's technical and hands-on curricula, a unique pedagogical structure was developed for the program that aims to support an integrative and collaborative approach to this shared design-research project. This is described in the diagram above. MSD-RAS studies are project research led, with students work supported through concurrent technology and writing courses that contribute to these same projects. It is easy to focus on developing high-quality research when all of your attention, and the faculty's is devoted to it.

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The MSD-RAS program is taught by some of the Weitzman School's most inter-disciplinary and internationally-experienced architecture faculty, while drawing on expertise from Penn Engineering and Computer Science departments to contribute expert knowledge in robotics, computer vision, electrical engineering, and more.

Penn's faculty are actively working on research and practice projects related to the core topics of the MSD-RAS, such as a full-scale precast concrete house prototype in collaboration with Cemex that leverages robot hot-wire cutting for the production of formwork molds, a robot curve-folded sheet-metal installation undertaken in collaboration with Robofold, or an additively manufactured wall installation fabricated from recycled PETG.

Robert Stuart-Smith
MSD-RAS Program Director,
Assistant Professor of Architecture

Robert Stuart-Smith is the Director of the MSD-RAS degree program, Assistant Professor of Architecture, and Affiliate Faculty in Engineering's GRASP Lab at the University of Pennsylvania. He leads the Autonomous Manufacturing Lab in Penn's Department of Architecture and University College London's Department of Computer Science, managing over $5 million in research and collaborating with industry partners such as Cemex, Skanska, Mace, Burohappold, and Ultimaker. Stuart-Smith's research intersects design, computation, robotic fabrication, and collective robotic construction. His Aerial Additive Manufacturing research, published in Nature, demonstrates the first in-flight additive manufacturing by cooperating drones. Integrating robotic manufacturing with architectural design, Stuart-Smith addresses the environmental and economic costs of production while enhancing their cultural and aesthetic impacts. He co-directs Robert Stuart-Smith Design and was a co-founder of Kokkugia. Author of the book *Behavioural Production*, he has published in journals including *Nature*, *Science Robotics*, and *AD Architectural Design*. Included in the permanent collection at Frac Centre-Val de Loire, his work has been exhibited at Venice, Tallinn, Beijing, and Prague Architecture Biennales. He has taught at AA, WashU, RMIT, U.Innsbruck, and lectured at institutions such as ETHZ, U.Stuttgart, MIT, CCA, Sci-Arc, AA, Angewandte, Strelka Institute, and Tsinghua. His work has been featured by BBC Click, New Scientist, Smithsonian, Architizer, France 3, and others.

Andrew Saunders
Associate Professor of Architecture

Andrew Saunders is an associate professor of Architecture at the University of Pennsylvania Stuart Weitzman School of Design where he serves as the associate chair of the Department of Architecture and director of the Master of Architecture Professional Degree Program, as well as teaching studios in the Master of Science in Design: Robotics and Autonomous Systems (MSD-RAS) program. He is founding principal of Andrew Saunders Architecture + Design, an internationally published, award winning architecture, design and research practice committed to the tailoring of innovative digital methodologies to provoke novel exchange and reassessment of the broader cultural context. The practice innovates at several scales ranging from product

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design, exhibition design, and residential and large-scale civic and cultural institutional design. He received his Bachelor of Architecture from the University of Arkansas and a masters in Architecture with Distinction from the Harvard Graduate School of Design. His current practice and research interests lie in computational geometry as it relates to aesthetics, emerging technology, fabrication, and performance. Due to the multiplicity of overlapping research interests, he has published significantly in an array of fields. Recent work includes groundbreaking LiDAR survey analysis in his book, *Baroque Topologies* published by Palombi Editori and unprecedented integration of robotic fabrication with AI design methodologies in the permanent installation, Deep Relief. He has significant professional experience as project designer for Eisenman Architects, Leeser Architecture, and Preston Scott Cohen, Inc. He has taught and guest lectured at a variety of institutions, including Cooper Union and the Cranbrook Academy of Art, and was an assistant professor of Architecture and head of graduate studies at Rensselaer Polytechnic Institute in New York.

Nathan King

Senior Industry Futures Manager @ Autodesk.

Dr. Nathan King is a senior industry futures manager at Autodesk and contributes to strategic initiatives related to robotics, automation, manufacturing, and construction. In addition, he was instrumental in the creation of the Autodesk Technology Centers and continues to work with industry to catalyze innovation opportunities. Prior to joining Autodesk, Nathan was a director at Mass Design Group where he focused on the development of building technologies, medical devices, and evaluation methods for use in resource-limited settings. King is active in industry, practice, academia, and policy – working to create opportunities at their intersection. Nathan's work spans the globe, with built work in Malawi, Rwanda, Tanzania, Uganda, Haiti, Sweden, Dominican Republic, United States, and beyond. Dr. King is co-diretor of the Center for Design Research at Virginia Tech where he leads several programs focusing on design technology and impact design, including an initiative focused on the democratization of design technology through collaboration with the regions HBCUs and funded research focusing on automation in construction in the US's rural south. He is also a lecturer in Architecture at the Harvard University Graduate School of Design where he teaches courses in digital material systems and instructor at the University of Pennsylvania Stuart Weitzman School of Design, focusing on robotics and autonomous systems in design and construction. Nathan regularly teaches as part of AIA, ACADIA , RobArch, and other conferences, lectures widely, and publishes often including co-authoring of the book *Ceramics Material Systems in Architecture and Interior Design*. Currently, Dr. King is co-developing a Liberian vocational school that will close skills gaps and provide job opportunities in the country's agriculture, textiles, and construction trades.

Laia Mogas-Soldevila

Assistant Professor of Architecture
Director DumoLab Research

Laia Mogas-Soldevila is an Assistant Professor of Graduate Architecture and Director of DumoLab Research at the Stuart Weitzman School of Design, University of Pennsylvania. Laia's research focuses on radically sustainable material practices bridging science, engineering, and the arts. Her pedagogy supports novel theory and applied methods understanding biomaterials and bio-based fabrication in product design and architecture. Over the past ten years while teaching at UPC, MIT, Cornell, and Penn, Laia has built scholarship reconsidering matter as a fundamental design driver and partnering with scientists to redesign it towards unprecedented environmental capabilities. She has recently received the prestigious Johnson&Johnson Foundation Woman in STEM2D Scholar Award as well as Penn Grants by the Research Foundation, Environmental Innovation, Sachs Art Innovation, and Global Engagement Fund. Her work has been shown at the NYC and SF MoMA as part of Mediated Matter Group in 2022, at Milan's and London's Design Weeks in 2023, the ICA Philadelphia for ACADIA 2023, the Athens Opera House during Nostos Festival 2021, and at the Barcelona D-HUB for Design Does 2020. Laia holds an interdisciplinary doctorate bridging biomaterials science, biomedical engineering, and advanced design from Tufts University School of Engineering, two master's degrees from the Massachusetts Institute of Technology School of Architecture, and is a licensed architect with a minor in Fine Arts by the Polytechnic University of Catalonia School of Architecture in Barcelona and the École Nationale Supérieure de Beaux-Arts in Paris.

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Jeffrey Anderson

Lecturer in Architecture

Jeffrey Anderson is an educator, architectural designer, and AR/VR software developer. He currently teaches design studios and advanced media seminars in the Graduate Architecture and Urban Design program at Pratt Institute and the Graduate Architecture Program at the University of Pennsylvania. He is also the lead software developer in the Design Lab at Mancini Duffy where he conducts design research and develops architectural visualization tools. His current software development work focuses on creating new forms of physical and virtual collaboration that empower all members of the design process. His research focuses on using technology to create new relationships between users, architecture, and its context through interaction, sensing and feedback, and mixed reality. His recent book, *The Ecologies of the Building Envelope: A Material History and Theory of Architectural Surfaces* (Actar 2021), written with Alejandro Zaera Polo, analyses how social, political, technological, and economic forces have become embedded within architecture over the last century. His 2017 book, *Imminent Commons: The Expanded City*, edited with Alejandro Zaera Polo situates contemporary urbanism through the lens of ecological and technological resources relevant to all cities. He holds a Master of Architecture II from Princeton University, and both a Master of Architecture and a Bachelor of Science in Architecture from the Knowlton School of Architecture at Ohio State University.

Alicia Nahmad Vazquez

Lecturer @Penn, Associate Prof. @UofC

Alicia Nahmad is an architect with a passion for robotics and digital fabrication. As a research-based practising architect, for the last 12 years, she has been engaged with the digitization of building trades and adapting advanced digital design and robotic fabrication methods to incorporate the wisdom and craft of traditional building cultures. Her projects include the construction of award-winning 'Knit-Candela' and diverse collaborations with practice and academic institutions such as ZHA CODE , Block research group at ETH, IAAC, ODICO, and more. She holds a PhD from Cardiff University and a MArch from the AADRL. She has developed workflows for human-robot collaboration in the design and construction process that engage with local communities using advanced technologies. Alicia's work expands across a number of scales, from architectural pavilions to robotic installations and furniture. As an academic and an entrepreneur, Alicia is the founder of The Circular Factory (CF), and MITollbox. Alicia works as an Associate Professor at the University of Calgary SAPL. She also co-directs the Laboratory for Integrative Design. Before joining SAPL, she worked as studio master at the AADRL for 5 years. Previously, Alicia worked developing digital tools for practices like Populous and Zaha Hadid Architects. Her work has been published in numerous conferences and journals an she has lectured internationally on related topics.

Emek Erdolu

Lecturer @Penn

Emek Erdolu holds a PhD. in Computational Design from Carnegie Mellon University (CMU) School of Architecture. Situated across architecture, design computation, human-computer interaction, and robotics, Emek's research includes two main strands: one that focuses on building intuitive and interactive computational tools to support architectural practices, research, and education; and another one on the questions of computation, representation, and work within historical and contemporary architectural practices. His PhD research focused on AI/robotic systems we work with every day, investigating how building tasks are analyzed and decomposed to inform on-site robotic systems and how these systems reconfigure the organization of these tasks with new workflows and human-machine interactions they introduce to construction sites, focusing on a selection of historical and contemporary robotics practices in the United States. Part of this research has been co/published in the *Proceedings of the ACM on Human-Computer Interaction (PACMHCI)*, the *International Journal of Architectural Computing (IJAC)*, and presented in venues such as the Society for Social Studies of Science (4S). Previously, Emek was a researcher at the ETH Future Cities Laboratory (FCL). In the United States, China, and Southeast Asia, he also worked in various architecture, landscape architecture, and urban design projects with AECOM, HMD, Ecoland, and Nomad Studio. He has lectured and taught studios in CMU, Singapore University of Technology and Design (SUTD), National University of Singapore (NUS), and Bilkent University. Aside from MSD-RAS at Weitzman, he has also taught in CMU's Master of Science in Computational Design (MSCD) program.

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Patrick Danahy

Lecturer @Penn & Emerging Scholar in Design @UTexas

Patrick Danahy is an assistant research professor of Architecture and the Design Innovation Fellow at Ball State University and the 2022 distinguished professor of the T4T Lab at Texas A&M, a position formerly held by Casey Rehm, Roland Snooks, Tom Wiscombe, Barry Wark, Gilles Retsin, Nate Hume, and other distinguished faculty. He has taught digital workshops in the UCL Bartlett RC20 Skills-Share program, as well as design and technology studios at the University of Pennsylvania as a part-time lecturer for the Master of Architecture and MSD-RAS programs, and as a visiting lecturer for the Landscape Architecture master's program. His teaching focuses on computation and robotics, integrating architectural reference with contemporary machine learning methods. Danahy holds a Bachelor of Arts in Architecture from Clemson University, where he received the graduating Faculty award and the Peter Lee and Kenneth Russo Award for Design Excellence. He later graduated from the University of Pennsylvania with a Master's of Architecture, receiving the Kanter-Tritsch Prize in Energy and Architectural Innovation, the Paul Cret T-Square Fellowship, the Van Alen Traveling Fellowship, the Dales Fellowship, the Kohn Fellowship, the Schenk-Woodman Merit Award, and, upon graduating, was awarded the Arthur Spayd Brooke Memorial Silver Medal. His work has been presented and published at the 2020 Digital Futures Young conference, the 2020 Distributed Proximities ACADIA conference, and the 2022 CAADRIA Post Carbon conference, receiving the award for best presentation runner up with Robert Stuart-Smith.

ARI Robotics Lab

The ARI Robotics Lab facility is where MSD-RAS students undertake most of their work. Full-time lab managers' primary role is in the development, safety, and operational aspects of the facilities, and in managing several part-time staff. However, beyond the faculty and TAs, lab managers also support student activities in the robotics lab. In the MSD-RAS program, robotics lab managers are essentially faculty, knowledgable in the work and methods of the program and excited to work with students to support their project work.

Nicholas Sideropoulos

ARI Robotics Lab Manager

Nicholas Sideropoulos is an Advanced Research & Innovation Lab (ARI) Robotics Lab Manager at the University of Pennsylvania, Weitzman School of Design. Sideropoulos holds a BArch from Rensselaer Polytechnic Institute and a Master of Science in Design: Advanced Architectural Design from the University of Pennsylvania's Weitzman School of Design.

Shunta Moriuchi

ARI Robotics Lab Manager

Shunta Moriuchi is an Advanced Research & Innovation Lab (ARI) Robotics Lab Manager at the University of Pennsylvania, Weitzman School of Design. Moriuchi holds a BArch from Calfornia College of the Arts and a Master of Science in Design in Robotics and Autonomous Systems from the University of Pennsylvania.

ARI Robotics Lab Senior Management

Robert Stuart-Smith and Karl Wellman

FACILITIES – THE ADVANCED RESEARCH AND INNOVATION ROBOTICS LAB

MSD-RAS students utilize Penn's ARI Robotics Lab facility that houses state-of-the-art industrial robots and experienced staff. The facility includes several ABB and UR robots and provides a flexible production space for individual and team-based robot production. Considerable investment in auto-tool changing capabilities enables an extensive range of production activities to be undertaken with minimal set-up time such as robotic milling, additive manufacturing, sheet-metal bending, or robot hot-wire cutting. The Robotics Lab also houses several high-performance 3D printers, pre and post-production work spaces and equipment for supporting fabrication and robot tooling development, such as a large cubical kiln. Students in the MSD-RAS are trained to utilize industrial robots and other equipment, and it is expected that a considerable amount of their design-research is developed through robotically fabricated prototypes and the development of robot programs and/or end-effector tools.

DEVELOPING NOVEL RESEARCH – MSD–RAS THESIS PROJECTS

MSD-RAS student thesis projects are often published and presented in world-leading conferences. A selection of recent research papers can be viewed online:

Wu, R., S. Moriuchi, S. Li, A. Chen, J. Anderson, Dr. N. King, and R. Stuart-Smith. “Dynamic Slip Casting: An Efficient Robotic Approach to Geometrically Variable Ceramic Part Production.” In ACADIA 2023: Proceedings of the 43rd Annual Conference of the Association of Computer Aided Design in Architecture (ACADIA): Habits of the Anthropocene, edited by A. Crawford, N. Diniz, R. Beckett, J. Vanucchi, and M. Swackhamer, 381-392. La Vergne: IngramSpark, 2023.

Vakhshouri, P., J. Luo, S. Su, H. Tang, B. Wang. B. Faircloth, Dr. N. King, and R. Stuart-Smith. “Ceramic Forest: Robotic Die-Extrusion Variable Forming for Architectural Ceramics.” In ACADIA 2023: Proceedings of the 43rd Annual Conference of the Association of Computer Aided Design in Architecture (ACADIA): Habits of the Anthropocene, edited by A. Crawford, N. Diniz, R. Beckett, J. Vanucchi, and M. Swackhamer, 381-392. La Vergne: IngramSpark, 2023.

Dunaway, D., D. Rothbart, L. Gwinn, Dr. N. King, and R. Stuart-Smith. “Introducing Bespoke Properties to Slip-Cast Elements: Designing a Process for Robotically Controlled Rotational Casting.” In Hybrids and Haecceities: Proceedings of the 42nd Annual Conference of the Association for Computer Aided Design in Architecture, edited by M. Akbarzadeh, D. Aviv, H. Jamelle, and R. Stuart-Smith, 244-255. La Vergne: IngramSpark, 2022.

Li, C., Yuan, M., Zilong, H., Faircloth, B., S. Anderson, J., King, Dr. N., & Stuart-Smith, R. (2022). “Smart Branching: An Experimental Method for Heterogeneous Branching Networks using Non-planar 3D Printed Clay Deposition”. In Hybrids and Haecceities: Proceedings of the 42nd Annual Conference of the Association for Computer Aided Design in Architecture, edited by M. Akbarzadeh, D. Aviv, H. Jamelle, and R. Stuart-Smith, 90-97. La Vergne: IngramSpark, 2022.

Wang, Y., Y. Liu, R. Studebaker, B. Faircloth, and R. Stuart-Smith. “Ceramic Incremental Forming: A Rapid Mold-less Forming Method of Variable Surfaces.” In Hybrid Intelligence: Proceedings for the 4th Conference on Computational Design and Robotic Fabrication (CDRF), edited by P.F. Yuan, H. Chai, c. Yan, K. Li, and T. Sun, 499-513. Singapore: Springer Nature Singapore, 2022.

ADMISSIONS + NEXT STEPS

Read specific information regarding admissions.
Applicants must submit three letters of recommendation, transcripts from each college or university attended for credit, a résumé, a digital portfolio of design work, one writing sample, a description of computing skills and software proficiency, and a personal statement describing his/her educational goals in taking the program. Submission of GRE scores is optional. International applicants must submit official IELTS Academic, PTE Academic, or TOEFL scores if English is not their first language.

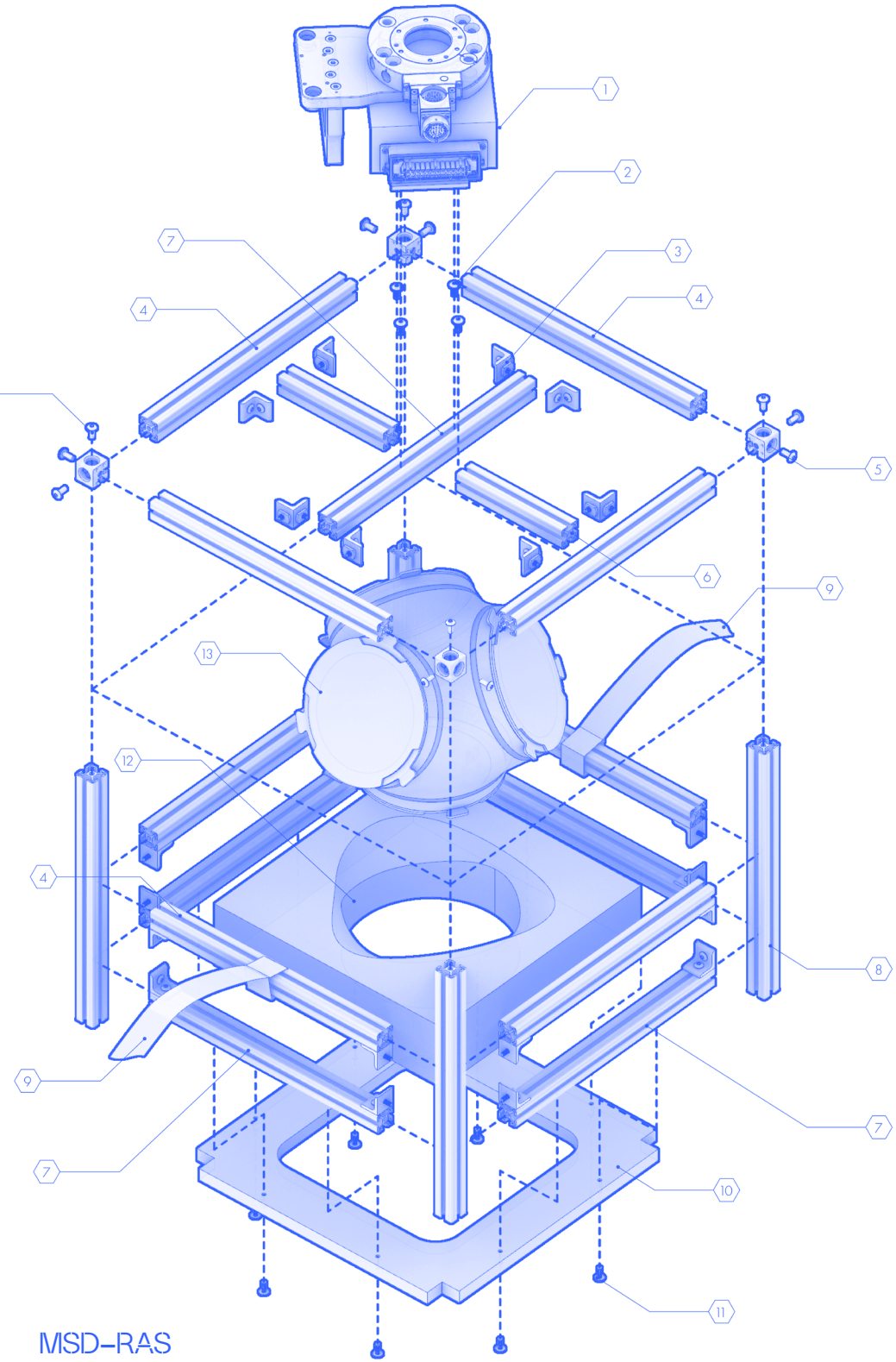
Program Director:
Robert Stuart-Smith, msd-ras@design.upenn.edu

Program Faculty:
Andrew Saunders, Alicia Nahmad Vazquez, Emek Erdolou, Jeffrey Anderson, Laia Mogas-Soldevila, Nathan King, Patrick Danahy, among others.

Department of Architecture Chair:
Rossana Hu

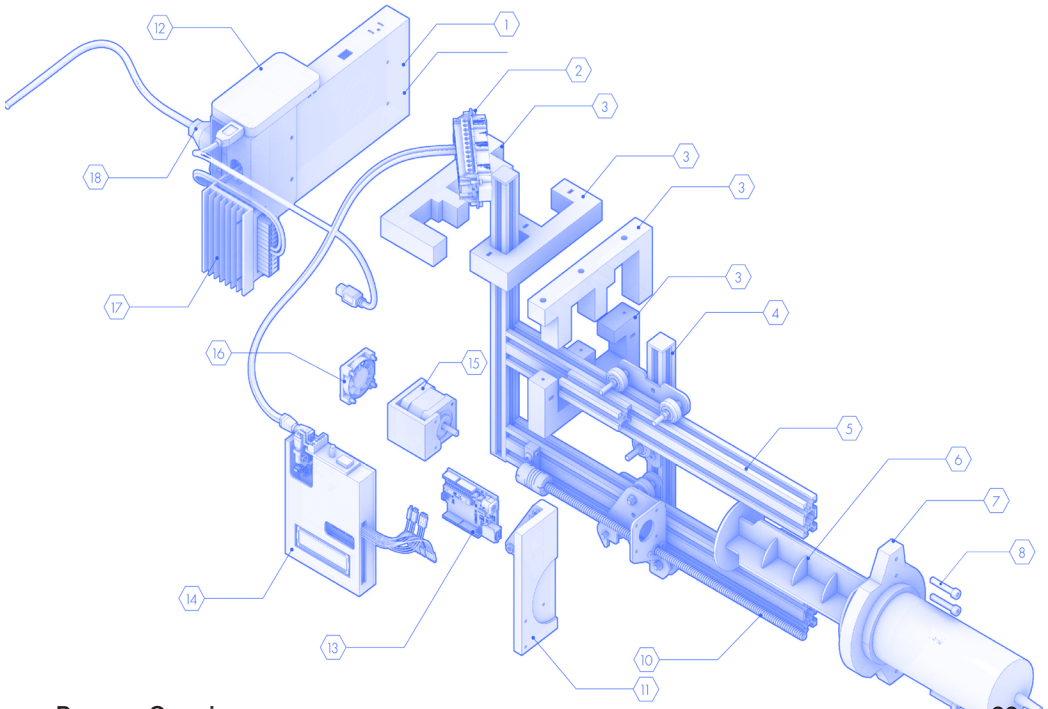
Key Dates:

Virtual Fall Open House: Monday, November 4
Applications Due: January 3, 2025
Spring Open House: To Be Announced
Program Orientation: To Be Announced
Classes begin: August 2025



“We learnt so much during the MSD-RAS program that when I started working in a tech start-up robotic fabrication company I realized I knew more about industrial robot programming and fabrication than any of my work colleagues”

– Ecem Karaduman,
recent MSD-RAS graduate.



FAQ

How much of the Program involves groupwork versus individual work?

Material Agencies: Robotics & Design Lab I & II involve group projects while the majority of the other courses involve individual submissions. There is ample opportunity to demonstrate individual knowledge whilst benefiting from the empowering capabilities of collaborative group work!

How Long is the MSD-RAS Program?

The MSD-RAS involves a 2-Week introductory course and two semesters. The program is full-time and can be completed in approximately 9 months.

Can I do the MSD-RAS part-time while working?

The MSD-RAS is a full-time program due to the fact that all course-work is inter-related to project-based assignments.

Is Financial Aid Available for the MSD-RAS?

Yes, the Weitzman School of Design awards scholarships to master's degree students based on merit and/or need. Need is determined for consideration for these awards, as well as for Federal loans and work-study, from the Free Application for Federal Student Aid (FAFSA) form for US citizens and permanent residents. Need is determined for international students from our International Student Application (www.design.upenn.edu/sites/default/files/uploads/International_Financial_Aid_Application_2020.pdf).

Are there elective studios in the MSD-RAS?

All MSD-RAS students undertake the same courses with the same professors with the exception of an elective course in the Fall Semester.

What qualifications will I have when I complete the course?

The course is a Master of Science in Design in Robotics and Autonomous Systems. It is offered in the University of Pennsylvania Stuart Weitzman School of Design's Department of Architecture and is a STEM certified course.

Is this an architectural design Masters degree?

The MSD-RAS is both a design and science degree. The MSD-RAS is open to anyone with a degree in architecture, the coursework is focused on design operating through material experimentation and robotically manufactured prototypes, with parallel support and training in computer programming and generative design methods. The Program is both speculative and hands-on! The department also offers Post-Professional degrees in Advanced Architectural Design (MSD-AAD) and in Environmental Building Design (MSD-EBD)

I don't have a degree in Architecture. Am I eligible to apply?

The MSD-RAS is primarily geared towards architectural graduates however, candidates from other fields whose prior experience and future career interests align with the program and who can fulfill the application requirements will be considered. If you believe this applies to you, we strongly encourage you to contact us so that we can help you determine whether your application would be considered.

I have a Masters degree in Architecture however, my Bachelor degree was in another field. Am I eligible to apply?

Yes.

FAQ

What skills can I expect to learn during the Program?

Participants will gain state of the art knowledge and experience in industrial robot fabrication and programming, design and computer programming skills, material research and application methods, academic writing skills and more.

Does Penn also offer a certificate similar to MSD-RAS?

No, if you are interested, you would need to undertake the MSD-RAS!

I don't have prior experience in robots or computer programming, can I apply?

The MSD-RAS program has been structured in such a way as to not require applicants to have prior knowledge or experience in computer programming or robotics however, prior knowledge and experience is helpful.

What software will be utilized and do I need to know these before starting the MSD-RAS?

Use of software programs varies with continual updates to the curricula. Where use of a specific software is required, training in the software will be provided. Commonly used software in the fields of design and robotic fabrication include: Rhino3D, Grasshopper, ABB RobotStudio, HAL, Visose Robots, ROS, Arduino, Processing, and others, in addition to Adobe Creative Suite and MS Office. Prior experience in these is helpful but not required.

What programming languages will classes utilize, and will I be taught these?

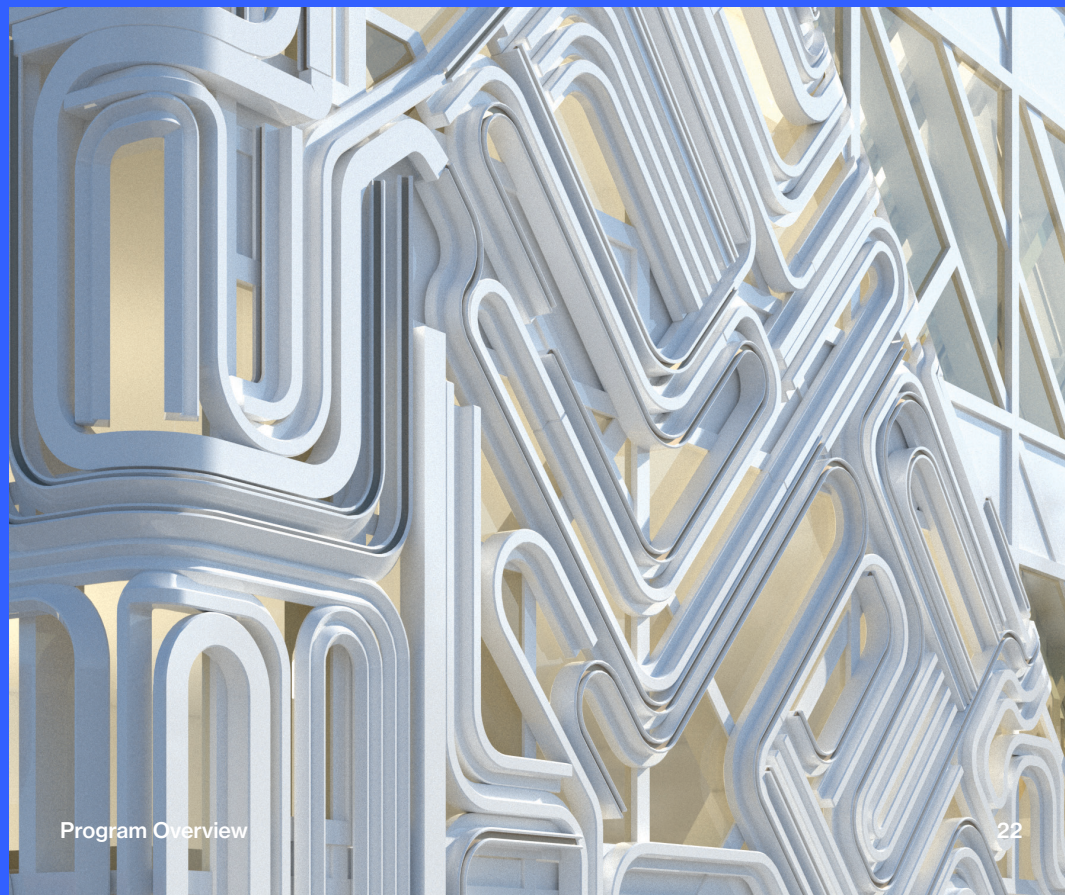
Programming languages vary with continual updates to the curricula. A MSD-RAS student can expect to be taught and to utilize at least two programming languages from the most common languages in use (python, java, C++, C#). Python is perhaps the most versatile language for daily use at present due to its easy adoption and broad support across many OS and software frameworks. Note that programming is taught for the purposes of the MSD-RAS applications in design and robot programming, and does not provide a comprehensive education into these languages suitable for other purposes such as web or software development. For those not accustomed to writing software, code can be learned by anyone in a short amount of time, and is far simpler than learning a second language.

Am I required to bring my own computer?

Yes. While the School has lab facilities, the MSD-RAS requires all students to have their own computer. If you are accepted into the program, we can provide you with minimum computer performance recommendations.

What Operating Systems am I able to use in the Program?

All students will be required to have Microsoft Windows installed on their computer. Some courses may utilize Linux for specific tasks, but no pre-installation is required.



HAVE QUESTIONS?

Drop us a line. We'd be happy to answer any remaining questions you might have about the MSD-RAS program.

Architecture Department

Office hours:
Monday through Friday 9:00-5:00

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