

MIT Beaver Works Summer Institute

# MIT Beaver Works Summer Institute 2023

## HIGH SCHOOL PROGRAM

Draper



Autonomous  
RACECAR  
Grand Prix



Autonomous  
Cognitive  
Assistant



Remote  
Sensing

AFOSR  
AF Office of Scientific Research



Build a  
CubeSat



UAS-SAR

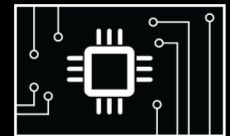
MITRE Project



Embedded  
Security and  
Hardware Hacking



Data Science for  
Health & Medicine



Microelectronics  
and Hardware  
Development



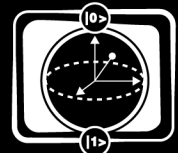
Serious Game Design  
and Development  
with AI

ONR Autonomous Maritime  
Engineering Project



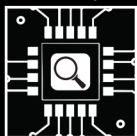
Autonomous  
Underwater  
Vehicle Challenge

MITRE Project



Quantum  
Software

MITRE Project



Back To bASICs



Cyber Operations



You are cordially invited to attend the

***2023 MIT Beaver Works Summer Institute (BWSI)  
Final Event and Awards Ceremony.***

Join us in cheering on the over 370 outstanding high school students from across the country as they participate in a series of challenges, races and demonstrations designed to showcase their hard work. You will also have the opportunity to meet many of the dedicated staff who taught and mentored the 2023 Class.

The entire virtual event will be hosted at <https://web.mit.edu/webcast/beaverworks/sum23/>

From this webpage you will be able to navigate anywhere you need to go to see the livestreamed in-person event on Saturday and the virtual event on Sunday. Make sure you bookmark this.

This is our first year as a hybrid program and so we are having both an in-person and virtual events to celebrate. We are excited to see the amazing things all our students have learned! See below for the full schedule.

All times are EDT. All locations are on MIT campus. All in-person events will also be livestreamed!

**August 5 2023 Schedule:**

11:00 -11:25am – Opening Remarks

11:30 - 12:55pm – Session 1

- Build A Cubesat (MAC Court); Unmanned Air System - Synthetic Aperture Radar (UAS-SAR) (31-270); Autonomous RACECAR Time Trials (Johnson Ice Rink)

1:00 - 2:30pm – Session 2

- Autonomous Racecar Time Trials (Johnson Ice Rink); Autonomous Underwater Vehicle Challenge (MAC Court); Unmanned Air System - Synthetic Aperture Radar (UAS-SAR) (31-270),

2:30 - 2:45pm – Break - All spectators, students and staff head to Johnson Ice Rink

2:45 - 3:00pm - RACECAR Grand Prix Virtual Race (Johnson Ice Rink) (this will be the final event for Saturday, at this time everyone should join us for the final race and closing ceremonies)

3:00 to 3:30pm – Team Awards and Closing Remarks (Johnson Ice Rink)

## August 6, 2023 Schedule:

11:00 -11:25am – Opening Remarks

11:30 - 12:55pm – Session 1

- Embedded Security and Hardware Hacking; Cyber Operations; Quantum Software; Medlytics, Serious Games for AI

1:00 - 2:30pm – Session 2

- Back to bASICs, Microelectronics, Autonomous Racecar; Remote Sensing, Autonomous Cognitive Assistant

2:30 - 2:45pm – Break - All spectators, students and staff main room on virtual event

2:45 - 2:55pm - Dr. Bob Berman Award for Disruptive Engineering

2:55 - 3:00pm - Diversity, Equity, and Inclusion Essay Awards

3:00 - 3:30pm – Team Awards

3:30 to 4:00pm – Closing remarks, including student and staff name scroll

Please share with as many as you would like to invite and attend to the final event. It is open to all. Evite link: <https://www.eventbrite.com/o/mit-beaver-works-34054434977>

We can't wait to see you there!



**MIT Lincoln Laboratory**



**MIT Lincoln Laboratory / School of Engineering Beaver Works**



**Massachusetts Institute of Technology**

# What is Beaver Works Summer Institute?

The MIT Beaver Works Summer Institute (BWSI) is a rigorous, world-class STEM program for talented students who will be entering their senior year in high school. The four-week program teaches STEM skills through project-based, workshop-style courses.

BWSI began as a challenge, a challenge to create a program to help students learn professional skills and advanced programming that was not available at the high school level! In 2016, we began with a single course offered to 46 students, a mix of local daytime students and out-of-state residential students. In this course, RACECAR (Rapid Autonomous Complex Environment Competing Ackermann steering), students programmed small robotic cars to autonomously navigate a racetrack, competing in teams.



The positive student reaction to our hands-on learning style led to the expansion of the program to include two new courses in 2017. To make sure students had the STEM background to participate fully in the three courses, the BWSI instructors developed online tutorials that students had to complete as a prerequisite for applying for the summer program. The new courses were Autonomous Air Vehicle Racing and Autonomous Cognitive Assistant. In 2017, 98 students from 49 high schools nationwide enjoyed BWSI.



We continued to grow both adding courses and students after switching to a virtual format in 2020 during the pandemic. In 2022, we offered 13 courses adding more autonomous systems, cyber-security, software and engineering courses. We have over 351 students participating in our program from over 200 high schools. It is one of most diverse group of students yet, with 43% young women. We also were able to support in-person program in on Kwajalein.

Our goals are to continue to find ways to provide project-based learning



opportunities where ever possible. We are looking for new courses that motivate students in new areas of autonomous technologies to data science and engineering. We are always looking for collaborators to scale up the program nationally and internationally, offering our curriculum high school STEM teachers. Our vision is a broad network of BWSI-like programs that will help improve engineering education, and toward that goal, we will share our work and ideas with universities and schools worldwide.

Contact us at [bws-admin@mit.edu](mailto:bws-admin@mit.edu) for information on how to adopt this program into your school curriculum.

# MIT Beaver Works Summer Institute

## 2023 Summer Program: Course Overview

The MIT Beaver Works Summer Institute ran the courses below in 2022 and we plan on running them all again, some will continue to be virtual and others will be in-person based MIT policy and space availability for 2023. We will make an official course announcement in early 2023. For more information on each course, see the following pages in this brochure.

### **Autonomous RACECAR Grand Prix**

Beaver Works Summer Institute will offer students, each with its own MIT-designed RACECAR robot, the opportunity to explore the broad spectrum of research in autonomy; learn to collaborate, and demonstrate fast, autonomous navigation in a Mini Grand Prix to ***Move... Explore... Learn...Race!***

### **Autonomous Cognitive Assistant**

Beaver Works Summer Institute will offer students an opportunity to learn about the cutting-edge in machine learning. Cog\*Works consists of project-based modules for developing machine learning apps that leverage audio, visual, and linguistic data. Students will work with experts in these fields to learn foundational mathematical, programming, and data analysis skills, which will enable them to create their own algorithms and neural networks from scratch. Ultimately, they will design their own cognitive assistants.

### **Build a CubeSat**

Beaver Works Summer Institute will offer students the opportunity to design, build, and test a prototype CubeSat. Students will explore all the major subsystems of a satellite and get hands on experience with mechanical, electrical, and software engineering. The class will use these new skills to demonstrate a real CubeSat science mission in partnership with scientists from Woods Hole Oceanographic Institution.

### **Microelectronics and Hardware Development**

Beaver Works Summer Institute will offer a brand new course on microelectronics and hardware development this summer. This course will provide students with an overview of how microchips, PCBs, and hardware systems are made and how they run the world. Students will receive hands-on experience on how to design and implement hardware systems using microcontrollers and develop useful electronics that can impact our daily lives. At the start of the summer, students will receive a basic hardware kit and can ask for additional items to be purchased so they can implement their own unique designs. No prior experience with hardware is necessary, and we encourage novices to participate.

### **Back To bASICs – MITRE Project**

Beaver Works Summer Institute will offer a brand-new course on open source semiconductor design and fabrication this summer. This course will give students a fundamental and working knowledge of **the** building blocks of today's electronic world—knowledge that will benefit the student no matter what they decide to pursue academically. Students will receive hands-on experience on how to design and arrange semiconductors on a nanometer scale to perform a specific function. Students will start with a blank canvas (silicon substrate) and learn how to take a specification through the entire design process—including foundry manufacturability. Once complete, the student's design will be sent to a foundry for fabrication. Six months later we'll host a class reunion and the students will be provided a dev kit with their custom design permanently etched in silicon—a milestone to be treasured for a lifetime!

### **Cyber Operations**

Beaver Works Summer Institute will help students learn and understand cyber security. The program will introduce students to techniques for conducting full-spectrum cyber operations from: networking, system administration, cyber threat intelligence, network defense, digital forensics, malware analysis, and additional cybersecurity techniques. The course will culminate a digital field training exercise (FTX) event consisting of several mystery tasks derived from several phases of the course.

### **Embedded Security and Hardware Hacking – MITRE Project**

Beaver Works Summer Institute will cover several cybersecurity topics with a focus on threats that are especially concerning for embedded systems. These topics include cryptography, embedded systems, software security, side-channel analysis, and fault-injection. This background will help prepare students for the summer course, during which they will design and perform security assessments of multiple implementations of an embedded system. They will learn the basics of embedded security and hardware hacking by designing a secure system and performing security assessments of classmates' designs to see who can find and fix the most security flaws.

### **Medlytics (Data Science for Health & Medicine)**

Beaver Works Summer Institute will give students a chance to explore the exciting intersection of data science and medicine. Students will build a solid foundation in the fundamentals of probability and statistics, and learn the basics of coding and machine learning techniques through a series of online teaching modules. During the summer, students will work in groups to gain hands-on experience applying advanced machine learning and data mining to solve real-world medical challenges.

### **Quantum Software - MITRE Project**

Beaver Works Summer Institute will offer students a chance to learn about quantum computing and algorithms. Students will learn fundamentals of quantum mechanics that make qubits unique and important to solving hard computational problems and develop algorithms that make use of qubit properties like superposition and entanglement. Students will be able to use quantum computing simulators to test their ideas and algorithms and explore the incredible opportunities with this technology.

### **Remote Sensing for Disaster Response**

Beaver Works Summer Institute Remote Sensing program will offer students the opportunity to explore the exciting intersection of data science and disaster response. The program consists of two components: (1) online course from February to May 2023, open to all interested and committed students; and (2) a four-week virtual summer program. During the course, the students will learn to understand the basics of Python, Git, GIS, machine learning, and image processing through a series of online teaching modules. Students will explore real world datasets featuring disaster imagery from both satellites and aerial platforms. Students in this course will develop experience in an area of data science that is poised to play a critical role in understanding our world.

### **Autonomous Underwater Vehicles Challenge**

This course will introduce students to the challenges faced by real-world ocean engineers in designing, building and programming autonomous underwater autonomous vehicles (AUVs). The culmination of the summer course will be an exciting test of true autonomy – the student AUVs will autonomously navigate a simulated underwater obstacle course, applying real-time decision making based on feedback from onboard sensors.

### **Unmanned Air System – Synthetic Aperture Radar**

Beaver Works Summer Institute will introduce students to Synthetic Aperture Radar (SAR) imaging as they build and fly a radar on a small Unmanned Aerial System (UAS) and use it to image scenes around campus. Students will work in small teams alongside their instructors to gain hands-on experience building, integrating, and processing data from a radar to generate SAR images. Teams will compete to create the UAS-SAR capable of producing the clearest images possible.



## MIT Beaver Works Summer Institute

### 2023 Summer Program Seminar Series





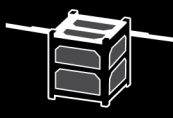




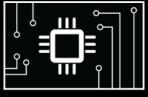
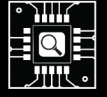


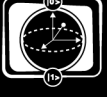
- July 11 (Tue): Prof. Ariel Furst, MIT Chemical Engineering  
*Taking inspiration from Nature: Bio-inspired systems for sustainability and clean energy*
- July 12 (Wed): Roberto Martinez, Sara Canzano, Phillip Daniel, Divya Shastry, Haixis Wang, MIT Lincoln Laboratory  
*DEI Panel Discussion*
- July 13 (Thu): Dr. Sajjan Saini, MIT Initiative for Knowledge and Innovation in Manufacturing  
*A New Way to Light a New Century: Integrated Photonics and the Future of the Information Age*
- July 14 (Fri): Dr. Eli Niewood, MITRE  
*System Analysis of an Engineer's Career (8 Things I Wish I had Known Before I Started My Career)*
- July 17 (Mon): Dr. Nandini Iyer, USAF AFMC AFOSR  
*Research Interests of the Air Force Office of Scientific Research in Life Sciences*
- July 18 (Tue): Dr. Eric Evans, Director, MIT Lincoln Laboratory  
*MIT Lincoln Laboratory Overview*
- July 19 (Wed): Chris Peterson, MIT Admissions Office  
*How to apply to MIT (and other colleges) as a Maker*
- July 20 (Thu): Dr. Deborah Campbell, MIT Lincoln Laboratory  
*Climate Change Challenges*
- July 24 (Mon): Dr. Jerry Wohletz, President and Chief Executive Officer, Draper  
*Draper's Legacy, Present, & Future*
- July 25 (Tue): Dr. Amrita Masurkar, BAE Systems FAST Labs  
*How to Build a Career in Semiconductor Devices*
- July 26 (Wed): Prof. Darcy McRose, MIT Civil and Environmental Engineering  
*Understanding the Earth's soils one molecule at a time*
- July 27 (Thu): Dr. Athit Kao, RTX  
*STEAM in the Age of AI*
- July 31 (Mon): Dr. Christy Fernandez-Cull, CEO, DaVinci Wearables  
*Disciplined Entrepreneurship - Journey in Sports, Technology, VC and Startup*
- Aug 1 (Tue): Dr. Chelsey Walden-Schreiner, Patrick J. McGovern Foundation  
*Data, what is it Good for? Experiences with Data for Social and Environmental Impact*
- Aug 2 (Wed): Emma Bassein, John Deere  
*Navigating the twists and turns of a sustainable technology career*
- Aug 3 (Thu): Louie Lopez, Director of DoD STEM in OUSD/R&E  
*STEM Education and Pathways to the Department of Defense*











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## HIGH SCHOOL PROGRAM

AFOSR  
AF Office of Scientific Research

 <b>Draper</b>  <b>Autonomous RACECAR Grand Prix</b>	 <b>Autonomous Cognitive Assistant</b>	 <b>Remote Sensing</b>	 <b>Build a CubeSat</b>	 <b>UAS-SAR</b>	 <b>Serious Game Design and Development with AI</b>	
 <b>MITRE Project</b> <b>Embedded Security and Hardware Hacking</b>	 <b>Medlytics</b> <b>Data Science for Health &amp; Medicine</b>	 <b>Microelectronics and Hardware Development</b>	 <b>MITRE Project</b> <b>Back To bASiCS</b>	 <b>Cyber Operations</b>	 <b>ONR Autonomous Maritime Engineering Project</b> <b>Autonomous Underwater Vehicle Challenge</b>	 <b>MITRE Project</b> <b>Quantum Software</b>

### MIT Sponsors

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**BEAVER WORKS**  
Lincoln Laboratory | School of Engineering



# MIT Beaver Works Summer Institute



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