PROGRAM IN MEDIA ARTS AND SCIENCES

The Program in Media Arts and Sciences (MAS) focuses on the invention, study, and creative use of new technologies that change how we express ourselves, how we communicate with each other, how we learn, and how we perceive and interact with the world. The field draws on a number of other disciplines, including computer science, cognitive sciences, communications, design, and the expressive arts. The program offers undergraduate and graduate subjects and a graduate program leading to master’s and doctoral degrees. Its academic programs are intimately linked with the research programs of the Media Lab.

Inquiries
Additional information about the programs in Media Arts and Sciences, graduate admissions, research programs, and research assistantships may be obtained from MAS Headquarters (https://www.media.mit.edu/graduate-program/about-media-arts-sciences), Room E15-435, 617-253-5114.

Undergraduate Study
Most MAS undergraduate subjects are project oriented and relate to ongoing research within the Media Lab. Certain graduate subjects are open to advanced undergraduates (see Subjects for details). Undergraduate Research Opportunities Program (UROP) (http://catalog.mit.edu/mit/undergraduate-education/academic-research-options/undergraduate-research-opportunities-program) positions at the Media Lab are a major part of the MAS education offerings to undergraduates.

Graduate Study
Media Arts and Sciences offers a graduate program leading to master’s and PhD degrees. Graduate students work closely with a research advisor in an apprenticeship relationship. Students enter the program from a wide variety of backgrounds, including electrical engineering, physics, computer science, cognitive science, mechanical engineering, art and design, and the learning sciences.

For the master’s degree, students are required to spend at least four terms in residence (one of which may be a summer term) and to complete a satisfactory research thesis.

Students wishing to pursue a PhD degree must demonstrate exemplary progress in the master’s program and gain approval from a departmental committee review. Requirements for the PhD degree include successful completion of MAS general exams, and successful completion and defense of a dissertation based on original and significant research within one of the Media Lab’s research groups.

Financial Support
The Program in Media Arts and Sciences offers financial assistance to all successful applicants in the form of research assistantships within the Media Lab, which are an important part of the educational program. Research assistants receive academic credit for part of their research activities.

Faculty and Teaching Staff
Tod Machover, MM
Muriel R. Cooper Professor of Music and Media
Academic Head, Media Arts and Sciences Program

Joseph A. Paradiso, PhD
Alexander W. Dreyfoos (1954) Professor in Media Arts and Sciences
Associate Academic Head, Media Arts and Sciences Program

Professors
Edward S. Boyden III, PhD
Y. Eva Tan Professor in Neurotechnology
Professor of Brain and Cognitive Sciences
Professor of Media Arts and Sciences
Professor of Biological Engineering

Cynthia Lynn Breazeal, PhD
Professor of Media Arts and Sciences

Neil Gershenfeld, PhD
Professor of Media Arts and Sciences

Hugh M. Herr, PhD
Professor of Media Arts and Sciences

Hiroshi Ishii, PhD
Jerome B. Wiesner Professor of Media Arts and Sciences

Patricia Maes, MM, PhD
Professor of Media Technology

Alex Pentland, PhD
Toshiba Professor of Media Arts and Sciences
Member, Institute for Data, Systems, and Society

Rosalind W. Picard, ScD
Professor of Media Arts and Sciences

Mitchel Resnick, PhD
LEGO Professor of Learning Research

Deb K. Roy, PhD
Professor of Media Arts and Sciences
Associate Professors
Fadel Adib, PhD  
Doherty Chair in Ocean Utilization  
Associate Professor of Media Arts and Sciences  
Associate Professor of Electrical Engineering and Computer Science

Joseph Jacobson, PhD  
Associate Professor of Media Arts and Sciences

Neri Oxman, PhD  
Associate Professor of Media Arts and Sciences

Ramesh Raskar, PhD  
Associate Professor of Media Arts and Sciences

Assistant Professors
Canan Dagdeviren, PhD  
LG Career Development Professor of Media Arts and Sciences  
Assistant Professor of Media Arts and Sciences

Kevin Esvelt, PhD  
NEC Career Development Professor of Computer and Communications  
Assistant Professor of Media Arts and Sciences

Ekene Ijeoma, MA  
ABC Career Development Professor of Media Arts and Sciences  
Assistant Professor of Media Arts and Sciences

Deblina Sarkar, PhD  
AT&T Career Development Professor of Media Arts and Sciences  
Assistant Professor of Media Arts and Sciences

Danielle Wood, PhD  
Benesse Corporation Career Development Professor of Media Arts and Sciences  
Assistant Professor of Media Arts and Sciences

Visiting Professors
William D. Hillis, PhD  
Visiting Professor of Media Arts and Sciences

Adjunct Associate Professors
Zachary Lieberman, MFA  
Adjunct Associate Professor of Media Arts and Sciences

Lecturers
Joost Paul Bonsen, MS  
Lecturer in Media Arts and Sciences

Mark Feldmeier, PhD  
Lecturer in Media Arts and Sciences

Research Staff

Senior Research Scientists
Andrew B. Lippman, MS  
Senior Research Scientist of Media Arts and Sciences

Principal Research Scientists
Kent Larson, BArch  
Principal Research Scientist of Media Arts and Sciences

Pratik Shah, PhD  
Principal Research Scientist of Media Arts and Sciences

Shuguang Zhang, PhD  
Principal Research Scientist of Media Arts and Sciences

Professors Emeriti
Barry Lloyd Vercoe, DMA  
Professor Emeritus of Media Arts and Sciences  
Professor Emeritus of Music

Undergraduate Subjects

MAS.131 Computational Camera and Photography  
Subject meets with MAS.531  
Prereq: Permission of instructor  
U (Fall)  
Not offered regularly; consult department  
3-0-9 units

Covers the complete pipeline of computational cameras that attempt to digitally capture the essence of visual information by exploiting the synergistic combination of task-specific optics, illumination, sensors, and processing. Students discuss and use thermal, multispectral, high-speed and 3-D range-sensing cameras, as well as camera arrays. Presents opportunities in scientific and medical imaging, and mobile phone-based photography. Also covers cameras for human computer interaction (HCI) and sensors that mimic animal eyes. Intended for students with interest in algorithmic and technical aspects of imaging and photography. Students taking graduate version complete additional assignments.  
R. Raskar
MAS.132 Mathematical Methods in Imaging
Subject meets with MAS.532
Prereq: Permission of instructor
U (Spring)
Not offered regularly; consult department
2-0-7 units
Surveys the landscape of imaging techniques and develops skills for conducting imaging research. Reviews technical and social aspects of the evolving camera culture and considers its role in transforming social interactions, reshaping businesses, and influencing communities worldwide. Explores innovative protocols for sharing and consumption of visual media, as well as novel hardware and software tools based on advanced lenses, digital illumination, modern sensors, and emerging image-analysis algorithms. Students taking graduate version complete additional assignments.
R. Raskar

MAS.453[J] Mobile and Sensor Computing
Same subject as 6.808[J]
Prereq: 6.033 or permission of instructor
U (Spring)
3-0-9 units
See description under subject 6.808[J].
H. Balakrishnan, S. Madden, F. Adib

MAS.490 Independent Study in Media Arts and Sciences
Prereq: Permission of instructor
U (Fall, Spring)
Units arranged
Can be repeated for credit.
Special projects on group or individual basis. Registration subject to prior arrangement of subject matter and supervision by staff.
Staff

MAS.491 Independent Study in Media Arts and Sciences
Prereq: Permission of instructor
U (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.
Special projects on group or individual basis. Registration subject to prior arrangement of subject matter and supervision by staff.
Staff

MAS.UR Undergraduate Research in Media Arts and Sciences
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.
Individual or group study, research, or laboratory investigations under faculty supervision, including individual participation in an ongoing research project. See UROP coordinator for further information
C. Schmandt

MAS.URG Undergraduate Research in Media Arts and Sciences
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.
Individual or group study, research, or laboratory investigations under faculty supervision, including individual participation in an ongoing research project. See UROP coordinator for further information.
C. Schmandt

Graduate Subjects

MAS.531 Computational Camera and Photography
Subject meets with MAS.131
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units
Covers the complete pipeline of computational cameras that attempt to digitally capture the essence of visual information by exploiting the synergistic combination of task-specific optics, illumination, sensors, and processing. Studies discuss and use thermal, multi-spectral, high-speed and 3-D range-sensing cameras, as well as camera arrays. Presents opportunities in scientific and medical imaging, and mobile phone-based photography. Also covers cameras for human computer interaction (HCI) and sensors that mimic animal eyes. Intended for students with interest in algorithmic and technical aspects of imaging and photography. Students taking graduate version complete additional assignments.
R. Raskar
MAS.532 Mathematical Methods in Imaging
Subject meets with MAS.132
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
2-0-7 units

Surveys the landscape of imaging techniques and develops skills for conducting imaging research. Reviews technical and social aspects of the evolving camera culture and considers its role in transforming social interactions, reshaping businesses, and influencing communities worldwide. Explores innovative protocols for sharing and consumption of visual media, as well as novel hardware and software tools based on advanced lenses, digital illumination, modern sensors, and emerging image-analysis algorithms. Students taking graduate version complete additional assignments.

R. Raskar

MAS.533 Imaging Ventures: Cameras, Displays, and Visual Computing
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
2-0-7 units

Project-oriented seminar covers the opportunities and challenges for businesses based on emergent imaging innovations. Students analyze the landscape of imaging developments, plan business strategies and brainstorm towards a start-up, business unit, non-profit or citizen sector organization; they are encouraged to form teams and craft a business plan to gain practical experience in imaging research. Includes case studies of established and emerging businesses, and talks by invited business speakers. Surveys commercialization and the innovation landscape in all imaging arenas. Topics include mobile camera phones, cameras in developing countries, image-search, medical imaging, online photo sharing, and computational photography. Enrollment limited.

R. Raskar

MAS.534[J] Engineering Health: Understanding and Designing Affordable Health Diagnostics
Same subject as HST.928[J]
Prereq: None
G (Fall)
Not offered regularly; consult department
3-1-8 units

Designing and building novel health diagnostics and sensors while learning the fundamentals of rapid prototyping, applied optics, signals processing, imaging and other advanced sensing modalities. Students work in teams with a physician and technical mentor to design and construct a cutting edge health diagnostic or device. The best projects may be continued in the Spring semester through a clinical trials and ventures program reaching early trials by the end of the school year.

R. Raskar

MAS.535[J] Engineering Health: Designing and Deploying Affordable Health Diagnostics and Therapeutics
Same subject as HST.929[J]
Prereq: None
G (Spring)
Not offered regularly; consult department
6-0-0 units

Students design and construct a cutting-edge health diagnostic or device and explore opportunities to test and deploy it. Through structured interactions with physicians, and technical rounds at local hospitals, students incorporate user-centric design into their devices and engage with the health community towards implementation. Provides exposure to clinical trials, the FDA, user experience, intellectual property, and entrepreneurship.

R. Raskar

MAS.552[J] City Science
Same subject as 4.557[J]
Prereq: Permission of instructor
Acad Year 2020-2021: Not offered
Acad Year 2021-2022: G (Spring)
3-0-9 units
Can be repeated for credit.

Focuses on architectural and mobility interventions that respond to changing patterns of living, working, and transport. Emphasizes mass-customized housing, autonomous parking, charging infrastructure, and shared-use networks of lightweight electric vehicles (LEVs). Students work in small teams and are led by researchers from the Changing Places group. Projects focus on the application of these ideas to case study cities and may include travel. Invited guests from academia and industry participate. Repeatable for credit with permission of instructor.

K. Larson, R. Chin
MAS.600 Human 2.0
Prereq: Permission of instructor
Acad Year 2020-2021: Not offered
Acad Year 2021-2022: G (Spring)
0-9-0 units

Covers principles underlying current and future technologies for
cognitive, emotional and physical augmentation. Focuses on using
anatomical, biomechanical, neuromechanical, biochemical and
neurological models of the human body to guide the designs of
augmentation technology for persons with either unusual or normal
physiologies that wish to extend their cognitive, emotion, social or
physical capability to new levels. Topics include robotic exoskeletons
and powered orthoses, external limb prostheses, neural implant
technology, social-emotional prostheses, and cognitive prostheses.
Requires student presentations, critiques of class readings, and
a final project including a publication-quality paper. Enrollment
limited.
H. Herr

MAS.630 Advanced Seminar: Affective Computing and Ethics
Prereq: Permission of instructor
G (Fall)
2-0-10 units

Instructs students on how to develop artificial intelligence
technologies that help people measure and communicate emotion,
that respectfully read and that intelligently respond to emotion,
and that have internal mechanisms inspired by the useful roles
emotions play in humans. Students will also discuss ethical
questions that arise with the use of emotion-AI technologies and
how to prevent misuse. Topics vary from year to year, and may
include the interaction of emotion with cognition and perception;
the communication of human emotion via face, voice, physiology,
and behavior; construction of computers, agents, and robots having
skills of emotional intelligence; the role of emotion in decision-
making and learning; and ethical uses of affective technologies for
education, autism, health, and market research applications. Weekly
reading, discussion, and a term project required. Enrollment limited.
R. W. Picard

MAS.664[J] AI for Impact: Solving Societal-Scale Problems
Same subject as 15.376[J]
Prereq: None
G (Spring)
3-0-6 units
Can be repeated for credit.

Seminar promotes internal and external entrepreneurship, based on
artificial intelligence (AI) technologies, to increase understanding of
how digital innovations grow into societal change. Cases illustrate
examples of both successful and failed businesses, as well as
difficulties in deploying and diffusing products. Explores a range
of business models and opportunities enabled by emerging AI
innovations. Students craft a business analysis for one of the
featured technology innovations. Past analyses have become the
basis for research publications, and new ventures. Particular focus
on AI and big data, mobile, and the use of personal data.
R. Raskar, J. Bonsen A. Pentland

MAS.665[J] Development Ventures
Same subject as 15.375[J], EC.731[J]
Prereq: Permission of instructor
G (Fall)
3-0-9 units

Seminar on founding, financing, and building entrepreneurial
ventures in developing nations. Challenges students to craft
enduring and economically viable solutions to the problems faced
by these countries. Cases illustrate examples of both successful and
failed businesses, and the difficulties in deploying and diffusing
products and services through entrepreneurial action. Explores a
range of established and emerging business models, as well as
new business opportunities enabled by innovations emerging from
MIT labs and beyond. Students develop a business plan executive
summary suitable for submission in the MIT $100K Entrepreneurship
Competition’s Accelerate Contest or MIT IDEAS.
J. Bonsen, A. Pentland, C. Breazeal

MAS.690 Independent Study in Media Arts and Sciences
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged
Can be repeated for credit.

Opportunity for independent study under regular supervision by a
faculty member. Registration subject to prior arrangement of subject
matter and supervision by staff.
Staff
MAS.700 News and Participatory Media
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 units

Studies the news as an engineering challenge in light of recent, rapid, and ongoing changes to the way news is delivered and spread. Considers how we discover what events are taking place in different parts of the world and how we explain the importance of these events to readers or viewers, as well as how readers of a story respond to events. Explores the systems journalists and others have used to report and share the news. Focuses on developing one’s own tools and methods to address these challenges through weekly reporting assignments and a final project in which students build tools for journalists (professional and otherwise) to use. Limited to 18.
E. Zuckerman

MAS.712 Learning Creative Learning
Prereq: Permission of instructor
G (Spring; first half of term)
1-0-5 units
Can be repeated for credit.

An introduction to ideas and strategies underlying the design of new learning technologies. Focuses especially on technologies that support interest-driven, project-based, collaborative learning experiences. Students analyze innovative learning technologies, discuss underlying educational ideas, examine design principles, create new prototypes and applications.
M. Resnick

MAS.713 Projects in Creative Learning
Prereq: MAS.712 and permission of instructor
G (Spring; second half of term)
1-0-5 units

Building on concepts covered in MAS.712, students design new tools and activities based on the four P’s of creative learning: projects, passion, peer, and play.
M. Resnick

MAS.720 Scalable Civic Action
Same subject as 15.234
Prereq: None
G (Fall)
2-1-3 units

See description under subject 15.234. Open to undergraduates with permission of instructor.
S. Johnson, A. Lippman

MAS.750 Human-Robot Interaction
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
2-0-7 units

In-depth exploration of the leading research, design principles, and technical challenges in human-robot interaction (HRI), with an emphasis on socially interactive robots. Topics include mixed-initiative interaction, multi-modal interfaces, face-to-face communication, human-robot teamwork, social learning, aspects of social cognition, and long-term interaction. Applications of these topics to the development of personal robots for health, education, elder care, domestic assistance, and other domains will be surveyed. Requires student presentations, critiques of class readings, student projects, and a final project including a publication quality paper.
C. Breazeal

MAS.756 Principles of Awareness
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
0-9-0 units
Can be repeated for credit.

Experiential exploration of various theories and methodologies around awareness. Students keep an open lab book documenting methods and evaluations, and present their findings and observations regularly during class sessions. In the final project, students evaluate various tools, techniques, and interfaces around awareness targeted towards “performance” and “wellbeing.” Addresses themes, such as self vs. other, change, relational awareness, non-duality, and joy and happiness. In-class and virtual meetings consist of practice (ranging from meditation to hacking), lectures, and discussions with invited speakers/experts. Some of the talks will be open to the public. Limited to 20-25.
J. Ito, T. Priyadarshi
MAS.771 Autism Theory and Technology
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
2-0-10 units
Illuminates current theories about autism together with challenges faced by people on the autism spectrum. Theories in communicating, interacting socially, managing cognitive and affective overload, and achieving independent lifestyles are covered. In parallel, the course presents state-of-the-art technologies being developed for helping improve both theoretical understanding and practical outcomes. Participants expected to meet and interact with people on the autism spectrum. Weekly reading, discussion, and a term project required. Enrollment limited.
R. Picard

MAS.790 Independent Study in Media Arts and Sciences
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged
Can be repeated for credit.
Opportunity for independent study under regular supervision by a faculty member. Registration subject to prior arrangement of subject matter and supervision by staff.
Staff

MAS.808 Decoders 2.0: Microfabricated Devices
Prereq: Permission of instructor
G (Fall)
3-0-6 units
Can be repeated for credit.
Explores various microfabricated device layouts and their impacts on the world through guest lectures. Follows with literature review wherein students compose a summary paper based on representative papers published by the guest lecturers. As a final project, students write and publish on the class website a comprehensive perspective article based on guest lectures. May be repeated for credit with permission of instructor. Limited to 10; preference to Media Arts and Sciences students.
C. Dagdeviren

MAS.809 Decoders 1.5: Introduction to Microfabrication
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
3-6-3 units
Lectures along with cleanroom lab sessions (in Conformable Decoders' YellowBox) provide exposure to cleanroom processes and microfabrication techniques. Builds practical experience with all five components of the microfabrication techniques, including cleaning, deposition, patterning, etching, and testing. Working in small teams, students complete a midterm project in which they create a video of a microfabrication process demonstrated in the cleanroom. As a final project, students identify a problem that would be tackled with a collective device fabricated in the cleanroom in following semester. Students work throughout the term to develop a class booklet of microfabrication terms. Limited to 10 students, no listeners.
C. Dagdeviren

MAS.810 Decoders 1.6: Project Realization in Cleanroom
Prereq: MAS.809 and permission of instructor
G (Spring)
3-6-3 units
Builds on the combination of knowledge and skills learned in D1.5 (MAS.809) to guide students to develop their own mechanically adaptive (i.e., stretchable & flexible) piezoelectric systems and write an article about their research findings that will be published on course website by the end of term. Includes a mid-term project/contest in which students submit an image of a process and/or a device component with an artistic/personal view to illustrate how a personality reflects on projects and, more broadly, changes the society. Students also record short videos throughout the term which result in the final video of the project development. Limited to 10; no listeners.
C. Dagdeviren

MAS.825(J) Musical Aesthetics and Media Technology
Same subject as 21M.580(J)
Prereq: Permission of instructor
G (Fall)
3-3-6 units
In-depth exploration of contemporary concepts in music and media. Studies recent music that uses advanced technology, and the artistic motivations and concerns implied by the new media. Practical experience with computer music technology, including MIDI and post-MIDI systems. Special emphasis on the interactive systems for professionals as well as amateurs. Midterm paper and term project required.
T. Machover
**MAS.826[J] Projects in Media and Music**
Same subject as 21M.581[J]
Prereq: MAS.825[J]
G (Spring)
3-3-6 units
Can be repeated for credit.

Current computer music concepts and practice. Project-based work on research or production projects using the Media Lab's computer music, interactive, and media resources. Requires significant studio work and a term project. Projects based on class interests and skills, and may be individually or group-based. May be repeated for credit with permission of instructor.

*T. Machover*

**MAS.834 Tangible Interfaces**
Prereq: Permission of instructor
G (Fall)
3-3-6 units

Explores design issues surrounding tangible user interfaces, a new form of human-computer interaction. Tangible user interfaces seek to realize seamless interfaces between humans, digital information, and the physical environment by giving physical form to digital information and computation, making bits directly manipulable with hands and perceptible at the periphery of human awareness. In the design studio environment, students explore experimental tangible interface designs, theories, applications, and underlying technologies, using concept sketches, posters, physical mockups, and working prototypes.

*H. Ishii*

**MAS.836 Sensor Technologies for Interactive Environments**
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
3-3-6 units

A broad introduction to a host of sensor technologies, illustrated by applications drawn from human-computer interfaces and ubiquitous computing. After extensively reviewing electronics for sensor signal conditioning, the lectures cover the principles and operation of a variety of sensor architectures and modalities, including pressure, strain, displacement, proximity, thermal, electric and magnetic field, optical, acoustic, RF, inertial, and bioelectric. Simple sensor processing algorithms and wired and wireless network standards are also discussed. Students are required to complete written assignments, a set of laboratories, and a final project.

*J. Paradiso*

**MAS.837 Principles of Electronic Music Interfaces**
Prereq: Permission of instructor
Acad Year 2020-2021: Not offered
Acad Year 2021-2022: G (Fall)
3-0-9 units

Explores the ways in which electronic music is controlled and performed. A solid historical perspective is presented, tracing the development of various families of electronic musical controllers and instruments from their genesis in the late 1800s onwards. Design principles and engineering detail are also given for various current and classic controllers. Evolving issues in the control of computer music for live performance and interactive installations are discussed, including computer mapping of sensor signals and transduced gesture onto sound, music, and other media. Weekly reading assignments are given, and a final project or paper is required.

*J. Paradiso*

**MAS.841 Evolution: Natural and Directed**
Prereq: None
G (Spring)
Not offered regularly; consult department
3-0-9 units

Covers topics in molecular evolution, including mutation, recombination, evolvability, sexual reproduction and substitutes, experimental and directed evolution, genomic conflict, and gene drive. Features discussion-based critical analyses of the primary literature. At the end of the term, students prepare short research proposals emphasizing research strategy, experimental design, presentation, and writing. They also write a short grant proposal or manuscript intended for publication.

*K. Esvelt*
MAS.858 Asking How Space Enabled Designs Advance Justice and Development
Prereq: None
G (Fall)
3-0-9 units

Examines theoretical and practical challenges of applying complex technology, such as space systems, to advance justice and development within human society. Proposes and critiques a concept of justice and development based on attainment of the US Sustainable Development Goals. Analyzes text by historians and economists around global patterns of uneven technology access. Teaches systems engineering tools to analyze the context, stakeholders, functions and forms of complex systems that impact society. Presents six space technologies used for specific Sustainable Development Goal. Students read several text, discuss key themes, write reflective responses, and write a research proposal on a topic of their choice. Part of two-class series on space technology and sustainable development. Limited to 15.

D. Wood

MAS.859 Space Technology for the Development Leader
Prereq: None
G (Spring)
3-0-3 units

Follow on to MAS.858. Introduces intersections between space technology and sustainable development by examining technical, policy and social aspects of seven space technologies: satellite earth observation; satellite communication; satellite positioning; human space flight and micro gravity research; space technology transfer; fundamental scientific space research; and small satellites. Lectures introduce the US Sustainable Development Goals and show linkages to seven space technologies from the perspective of development practitioners. Students read scholarly papers, write weekly responses, give presentations, and write a research paper.

D. Wood

MAS.862 The Physics of Information Technology
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 units

Self-contained introduction to the governing equations for devices that collect, store, manipulate, transmit and present information. Provides an understanding of how operational device principles work, their uses, the limits on their performance, and how they might be improved. Students review the foundations of thermodynamics and noise, electromagnetics, and the quantum description of materials, and then study their application in areas such as semiconductor logic, magnetic storage, wireless and optical communications, and quantum information and computation.

N. Gershenfeld

MAS.863[J] How to Make (Almost) Anything
Same subject as 4.140[J], 6.943[J]
Prereq: Permission of instructor
G (Fall)
3-9-6 units

Provides a practical hands-on introduction to digital fabrication, including CAD/CAM/CAE, NC machining, 3-D printing and scanning, molding and casting, composites, laser and waterjet cutting, PCB design and fabrication; sensors and actuators; mixed-signal instrumentation, embedded processing, and wired and wireless communications. Develops an understanding of these capabilities through projects using them individually and jointly to create functional systems.

N. Gershenfeld, J. DiFrancesco, J. Lavallee, G. Darcey

MAS.864 The Nature of Mathematical Modeling
Prereq: Permission of instructor
Acad Year 2020-2021: Not offered
Acad Year 2021-2022: G (Spring)
3-0-9 units

Surveys the range of levels of description useful for the mathematical description of real and virtual worlds, including analytical solutions and approximations for difference and differential equations; finite difference, finite element and cellular automata numerical models; and stochastic processes, nonlinear function fitting, constrained optimization, and data-driven inference. Emphasis on efficient practical implementation of these ideas.

N. Gershenfeld
**MAS.865 Rapid-Prototyping of Rapid-Prototyping Machines: How to Make Something that Makes (Almost) Anything**
Prereq: MAS.863[J]
G (Spring)
3-9-0 units

Studies rapid-prototyping machines and covers the theory and practice of digital fabrication processes. Weekly lectures supported by readings from research literature. Students work on machine development projects throughout the term.

*N. Gershenfeld*

**MAS.881[J] Principles of Neuroengineering**
Same subject as 9.422[J], 20.452[J]
Subject meets with 20.352
Prereq: Permission of instructor
G (Fall)
3-0-9 units

Covers how to innovate technologies for brain analysis and engineering, for accelerating the basic understanding of the brain, and leading to new therapeutic insight and inventions. Focuses on using physical, chemical and biological principles to understand technology design criteria governing ability to observe and alter brain structure and function. Topics include optogenetics, noninvasive brain imaging and stimulation, nanotechnologies, stem cells and tissue engineering, and advanced molecular and structural imaging technologies. Includes design projects. Designed for students with engineering maturity who are ready for design. Students taking graduate version complete additional assignments. In person not required.

*E. S. Boyden, III*

**MAS.883[J] Revolutionary Ventures: How to Invent and Deploy Transformative Technologies**
Same subject as 9.455[J], 15.128[J], 20.454[J]
Prereq: Permission of instructor
G (Fall)
2-0-7 units

Seminar on envisioning and building ideas and organizations to accelerate engineering revolutions. Focuses on emerging technology domains, such as neurotechnology, imaging, cryotechnology, gerontechnology, and bio-and-nano fabrication. Draws on historical examples as well as live case studies of existing or emerging organizations, including labs, institutes, startups, and companies. Goals range from accelerating basic science to developing transformative products or therapeutics. Each class is devoted to a specific area, often with invited speakers, exploring issues from the deeply technical through the strategic. Individually or in small groups, students prototype new ventures aimed at inventing and deploying revolutionary technologies. In person not required.

*E. Boyden, J. Bonsen, J. Jacobson*

**MAS.890 Independent Study in Media Arts and Sciences**
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Opportunity for independent study under regular supervision by a faculty member. Registration subject to prior arrangement of subject matter and supervision by staff.

*Staff*

**General**

**MAS.910 Research in Media Technology**
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged
Can be repeated for credit.

For research assistants in Media Arts and Sciences, where the assigned research is approved for academic credit by the department.

*Staff*

**MAS.912 Teaching in Media Arts and Sciences**
Prereq: None
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory, tutorial, or classroom teaching under the supervision of a Media Arts and Sciences faculty member. Students selected by interview. Enrollment limited by availability of suitable teaching assignments.

*Staff*

**MAS.914 Practical Experience in Media Arts and Sciences**
Prereq: Permission of instructor
G (Fall, Spring, Summer)
0-1-0 units
Can be repeated for credit.

For Media Arts and Sciences masters students participating in curriculum-related off-campus professional internship experiences. Before enrolling, students must have an employment offer from a company or organization and approval from their advisor. Subject to departmental approval. Upon completion of the activity the student must submit a write-up of the experience, approved by the MIT supervisor. Consult the MAS Office for details on procedures and restrictions.

*MAS Staff*
**MAS.915 Practical Experience in Media Arts and Sciences**
Prereq: Permission of instructor
G (Fall, Spring, Summer)
0-1-0 units
Can be repeated for credit.

For Media Arts and Sciences doctoral students participating in curriculum-related off-campus professional internship experiences. Before enrolling, students must have an employment offer from a company or organization and approval from their advisor. Subject to departmental approval. Upon completion of the activity the student must submit a write-up of the experience, approved by the MIT supervisor. Consult the MAS Office for details on procedures and restrictions.

**MAS Staff**

**MAS.921 Proseminar in Media Arts and Sciences**
Prereq: Permission of instructor
G (Fall)
3-0-9 units

Designed specifically for new doctoral students in the Media Arts and Sciences (MAS) program. Explores intellectual foundations of MAS, unifying themes connecting MAS research, and working practices of MAS researchers. Restricted to MAS doctoral students.

*D. Roy*

**MAS.940 Preparation for SM Thesis I**
Prereq: Permission of instructor
G (Spring)
1-0-2 units

For first-year master’s students in the MAS program. Features faculty-led discussions on best practices for conducting and evaluating research in diverse disciplines, ways of assessing the consequences of new technologies, and strategies for mitigating unintended outcomes. Working in small groups, students share and critique research ideas to catalyze and refine projects and collaborations. By the end of the course, students will have identified potential committee members to help guide their thesis research.

*K. Esvelt, C. Breazeal*

**MAS.941 Preparation for SM Thesis II (New)**
Prereq: MAS.940 or permission of instructor
G (Fall)
3-0-6 units


*K. Esvelt, C. Breazeal*

**MAS.945 Media Arts and Sciences General Exam**
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
0-12-0 units
Can be repeated for credit.

Selected readings for Media Arts and Sciences doctoral students in preparation for their qualifying exams.

**Staff**

**MAS.950 Preparation for Ph.D. Thesis**
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Selects thesis subject, defines method of approach, and prepares preliminary thesis outline. Independent study, supplemented by frequent individual conferences with staff members. Restricted to doctoral candidates.

**Staff**

**MAS.S10 Special Subject in Media Technology**
Prereq: Permission of instructor
U (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.

**MAS Staff**

**MAS.S60-MAS.S64 Special Subject in Media Technology**
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged
Can be repeated for credit.

Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.

**MAS Staff**

**MAS.S65-MAS.S69 Special Subject in Media Technology**
Prereq: Permission of instructor
G (Spring)
Units arranged
Can be repeated for credit.

Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.

**Staff**
MAS.S70 Special Subject in Media Technology
Prereq: Permission of instructor
G (IAP)
Units arranged [P/D/F]
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.S71 Special Subject in Media Technology
Prereq: Permission of instructor
G (Fall, Spring; first half of term)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.S72 Special Subject in Media Technology
Prereq: Permission of instructor
G (Fall, Spring; second half of term)
Units arranged
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.S73 Special Subject in Media Technology
Prereq: None
G (Fall, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.S74 Special Subject in Media Technology
Prereq: None
G (Fall, Spring; first half of term)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.S75 Special Subject in Media Technology
Prereq: Permission of instructor
G (Fall, Spring; second half of term)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.S76 Special Subject in Media Arts and Sciences
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.S90 Special Subject in Media Arts and Sciences (New)
Prereq: Permission of instructor
G (Fall; partial term)
Units arranged [P/D/F]
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.S900 Special Subject in Media Arts and Sciences (New)
Prereq: Permission of instructor
G (Fall, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.
Supplementary work in areas not covered by the regular curriculum. Registration subject to prior arrangement.
Staff

MAS.THG Graduate Thesis
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.
Program of research and writing of thesis; to be arranged by the student with supervising committee.
Staff