Report of the Task Force on the Undergraduate Academic Program

Massachusetts Institute of Technology

May 20, 2026

Contents

Executive summary

The MIT undergraduate educational experience has always included both intellectual breadth and disciplinary depth. Through the advancement of perennial and enduring aims, it equips students with the habits of mind and the tools needed to think deeply, act responsibly, and lead with insight as they tackle complex problems in a rapidly changing world. These enduring aims include:

- Developing students' technical skills and a breadth of ways of thinking;
- Fostering students' ability to critically read, think, reason, and argue, enabling them to engage deeply with ideas across fields;
- Growing and strengthening students' ability to communicate effectively with broad and diverse audiences
- Ensuring that students not only master, but also creatively apply cutting-edge methods and tools in their disciplines.

To support and strengthen these aims, the Task Force on the Undergraduate Academic Program (TFUAP) was charged in Spring 2024 to undertake a systematic review of our undergraduate education and to provide recommendations to ensure MIT's prominence/ preeminence in the future.

In that time, TFUAP has:

- Met almost 100 times with groups across MIT (including multiple meetings with some groups), including academic departments, committees, councils, and relevant staff offices and groups
- Read reports, articles, and surveys on the state of MIT undergraduate education and undergraduate education more broadly
- Read and discussed more than 70 white papers submitted by the MIT community
- Met 1-on-1 with dozens of relevant stakeholders to assess the impact of possible changes
- Internally deliberated for well over a hundred and fifty hours

We have seen—first hand—the commitment and dedication to teaching and learning of our faculty and instructional staff, and the passion for high standards and intellectual depth in the education of the unique and amazing students who entrust us with their education. Our discussions with members of the community and our review of and reflection on past reports, articles, and surveys have highlighted the many aspects and attributes that are critical to the success and essence of an MIT education. Those aspects need to be nurtured and further strengthened.

The world is quite different now than it was in 1965, the last time MIT critically examined and substantially modified its core science curriculum. While the overarching aims of an MIT education remain, the specific educational goals we heard from the MIT community, reflecting the skills, knowledge, and qualities an MIT graduate should possess as well as the experience they ought to have on campus, are understandably different than those outlined a decade ago, let alone more than half a century. It was clear to us that MIT is not consistently meeting this new set of goals.

Therefore, TFUAP envisioned the changes necessary for MIT to maintain its preeminence in the future of higher education.

We have laid out a set of recommendations that will improve and strengthen the undergraduate experience overall, and better prepare our students for fulfilling, productive, responsible, and intellectually rich lives. We acknowledge that the recommendations will not be universally embraced, and that individual members of the community will take issue with isolated recommendations. We have sought to optimize a complex problem subject to the issues and constraints that surfaced in more than two years of listening, reading, and discussing. We are confident that we have succeeded, but we acknowledge that our recommendations involve trade-offs. We ask that readers keep the larger picture and all MIT students in mind while reading this report[1].

The overarching principles that guide the function of our set of common, required classes (i.e., the General Institute Requirements, or GIR) were defined by the RIC1 committee of Task Force 2021 as follows:

- Foundational Building Blocks: the GIRs provide a common body of knowledge that faculty can then assume in teaching advanced subjects. Courses fulfilling this function would serve as prerequisites for later courses for many students.
- Literacy in Essential Fields: the GIRs provide substantive knowledge in areas with which every MIT graduate should be familiar.
- Methods for Creative Analytical Thinking: the GIRs provide portable tools and strategies for formulating, analyzing, and solving problems.

After distilling community input and committee deliberations into a set of learning and process goals as shared in our Phase 1 report, it became clear that the current set of required classes (i.e., the GIRs) does not meet our goals, and that our graduates urgently need new skills and knowledge to grapple with the challenges of a digital age. Thus, we call for MIT to renew its curriculum with an adaptive structure that can continually **advance** MIT's educational mission in a rapidly evolving world. We also realized that the way forward was not merely to adjust the set of required classes, but that the classes interact closely with policies that can aid (or hinder) the achievement of those goals. Individual policies–and curricular choices–although carefully created to achieve particular aims, end up impeding the pursuit of our educational goals, so we propose to better **align** policies and curriculum with our aspirations and student needs. Finally, the intense and long-lasting effort required of committees such as ours (or the Silbey, Zacharias, Lewis, etc. committees) is in tension with the dynamic world in which we find ourselves, which calls for the ability to **adapt** more quickly than in the past. Our revised curriculum and the associated governance structures are intended to respond to rapidly evolving technical, societal, and campus needs and opportunities.

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[1] Much of the larger context and rationale is described below, and additional aspects and ongoing questions are addressed in the FAQ available at gue.mit.edu/tfuap/faq/.

Since the release of our draft report in February 2026, we have held town halls open to all community members, a town hall for students only, office hours for student feedback, and met with institute committees (CUP, CUAFA, UG admins, Dormcon, CSL) and individuals. We also received voluminous feedback via e-mail. TFUAP continued meeting weekly throughout the semester, collected relevant data, discussed feedback, and made adjustments on what would be included in the final report based on the feedback we received. Topics from the draft report that were discussed, and in some instances amended, include 1) Hands-on/experiential learning and the Lab requirement, 2) PSM requirement, 3) Feasibility and structure of Flexible foundations, including the need for catch-up classes, 4) Content of proposed 18.02, 5) Process for creating new SMC classes, 6) Flexible curriculum experiment, 7) Pilots to proposed policies, 8) MCP requirement placement, 9) Double-booking, 10) Engaged-classroom policy, 11) Pacing requirement, 12) UROP, 13) AP/ASE credit, 14) PE+W, 15) Drop date, 16) Moving registration. While we will not go into our rationale for specific revisions (or lack thereof) here, we direct you to an FAQ available at gue.mit.edu/tfuap/faq/ that touches on the discussions we had and our rationale for our final set of recommendations.

Advancing our curriculum

The current set of 17 subjects required of all MIT undergraduates is provided in the table below, and how they figure into a student's academic program is shown in the accompanying Figure 1.

<table>
<tr><th colspan="6">General Institute Requirements (GIRs)
17 subjects</th></tr>
<tr><th colspan="6">Science Core
6 subjects</th></tr>
<tr><td>Single-Variable Calculus</td><td>Multi-Variable Calculus</td><td>Mechanics</td><td>Electricity & Magnetism</td><td>Chemistry</td><td>Biology</td></tr>
<tr><th colspan="6">REST & Institute Lab
3 subjects</th></tr>
<tr><td colspan="4">Restricted Electives in Science and Technology (2 subjects)</td><td colspan="2">Institute Laboratory (1 subject)</td></tr>
<tr><th colspan="6">Humanities, Arts and Social Sciences (HASS)
8 subjects, including 2 communication-intensive (CI-H/HW in any category)</th></tr>
<tr><td colspan="6">Distribution Subjects
3 subjects, 1 from each category</td></tr>
<tr><td colspan="2">Humanities</td><td colspan="2">Arts</td><td colspan="2">Social Sciences</td></tr>
<tr><td colspan="6">Concentration Subjects
3-4 subjects as specified by the concentration department</td></tr>
</table>

Elective Subjects
1-2 subjects, depending on concentration

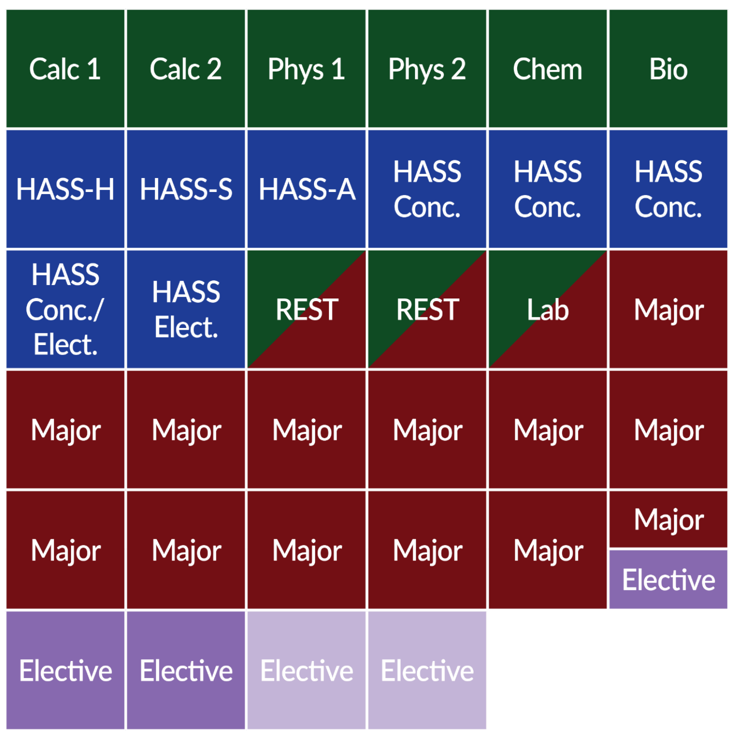
Communication-Intensive (CI-H/HW, CI-M)
4 subjects, two overlapping any HASS category, two in major

Physical Education & Wellness Requirement
8 PE+W points plus swim requirement

Major

Up to 12.5 additional subjects, including 2 communication-intensive (CI-M), plus majors can "specify or expect" up to 3 GIR subjects

Figure 1
Total Distribution of Subjects in Current Undergraduate Program, Assuming Maximum Major Size and Enrollment in 8-8.5 subjects/year for 4 years



**Maximum major size is 12.5 subjects, but majors may also specify up to 36 units of GIRs (typically REST and Lab, but sometimes HASS). Darker purple electives indicate 32 subjects total (includes required 180 units beyond GIRs), and lighter purple electives indicate 34 subjects total (maximum program size indicated in Faculty Rules and Regulations).*

There are many commendable aspects of this set of subjects. They provide MIT students with a rigorous and uniform core of science and math, along with rigorous training in the humanities, arts, and social sciences, both in breadth (via HASS distribution and SME GIRs) and depth (via HASS concentration and majors). The Institute Lab requirement provides some modicum of experiential learning for all students, with much more available via UROPs, extracurricular activities, and subjects in many majors.

However, there are several areas of concern with the current arrangement.

1. There was a desire by the committee, reflecting what we heard on our listening tour, to incorporate new disciplines and areas of focus (most notably computation, linear algebra, probability and statistics and machine learning, teamwork, and moral reasoning and reflection) into the required curriculum. In some cases, those are areas that students clearly consider to be essential (via the decision of what courses they already take) or that seemed essential to a broad section of the faculty. This stood in tension with the fact that adding requirements is not feasible (Figure 1 above shows just 2.5-4.5 unrestricted electives given the standard load of 8-8.5 subjects per year), and the desire by the committee to foster student choice and exploration wherever possible.
2. There is recognition that innovation often emerges at the intersections of fields, and that MIT can lead by integrating multiple disciplines, even within the common core, and educating students who move fluidly across boundaries.
3. Given the foundational nature of GIR subjects and the desire to introduce students to the range of opportunities at MIT, there was concern that some students take these GIRs late in their MIT careers.
4. The REST and Institute Lab requirements, though well-intentioned, have evolved–as they were absorbed by individual departments–in such a way that they do not serve the original Institute goals.
5. While the organization of the HASS subjects (into the H, A, and S categories) is an arrangement that helps emphasize the underlying disciplines and ensures breadth in HASS fields, the categories are too broad to ensure that every student grapples with questions of values and moral responsibility in a meaningful way.
6. We believe that the communication requirement needs to be adjusted to emphasize various forms of communication.

We thus propose the following revised set of 15 subjects required of all MIT undergraduates (table below), and show a student's academic program under the proposed requirements in the accompanying Figure 2.

General Institute Requirements (GIRs) *15 subjects*
Science, Math, and Computing Core *6-7 subjects (72 units)—To be taken in first 5 semesters*
Common Foundations—3 Subjects, 36 units

Single-Variable Calculus	Multi-Variable Calculus & Linear Algebra	Physics

Flexible Foundations/Essential literacy—4 subjects, 1 from each category, across at least 36 units of credit—choice of two subjects taken as 12-unit versions and two subjects taken as 6-unit or integrated versions

Chemistry	Biology	Computation	Probability, Statistics, & Machine Learning

Humanities, Arts and Social Sciences (HASS)
8 subjects, including 2 communication-intensive (CI-H/HW) and ***1 subject designated as "Moral and Civic Perspectives,"*** *which can overlap any category*

Distribution Subjects
3 subjects, 1 from each category

Humanities	Arts	Social Sciences

Concentration Subjects
3-4 subjects as specified by the concentration department, including at least 1 upper-level subject

Elective Subjects
1-2 subjects, depending on concentration

Teamwork Intensive Requirement
1 subject, may overlap with major or GIRs

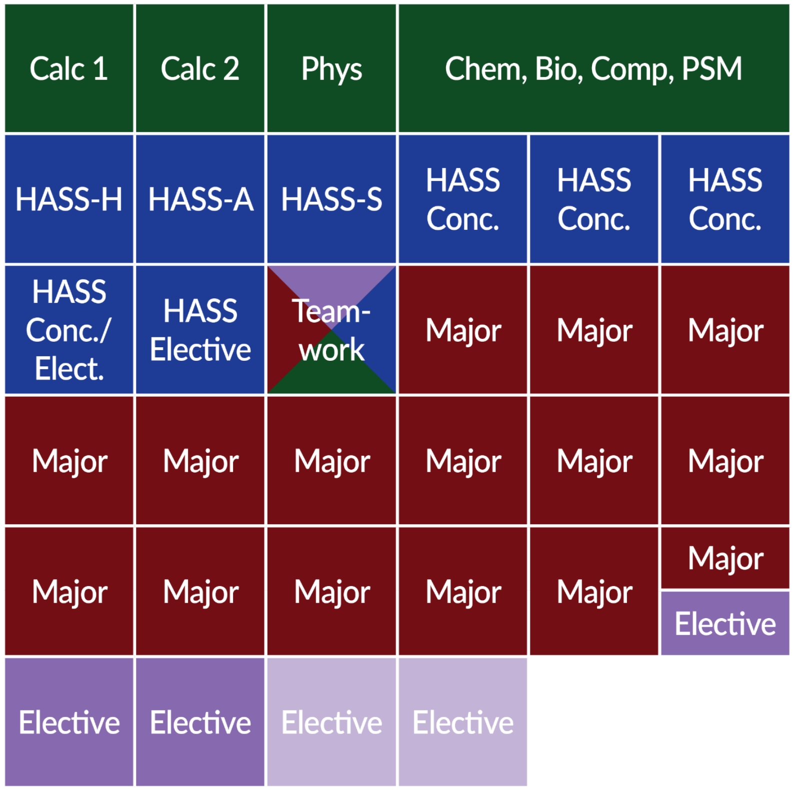
Communication-Intensive (CI-H/HW, CI-M)
4 subjects, two overlapping any HASS category, two in major

Physical Education & Wellness Requirement
8 PE+W points plus swim requirement

Major

Up to 14.5 additional subjects, including 2 communication-intensive (CI-M), or up to 15.5 subjects if at least 1 subject satisfies a GIR other than CI-M. In addition, majors may specify up to 2 Flexible Foundations topics that students must take as 12-unit subjects.

Figure 2
Total Distribution of Subjects in Proposed Undergraduate Program, Assuming Maximum Major Size and Enrollment in 8-8.5 subjects/year for 4 years



**Maximum major size is 14.5 subjects, but majors may also specify up to 12 units of GIRs (typically Teamwork-Intensive, but sometimes 12 units within Chem/Bio/Comp/PSM or HASS). Darker purple electives indicate 32 subjects total, and lighter purple electives indicate 34 subjects total (maximum program size indicated in Faculty Rules and Regulations).*

The table below shows a condensed view of the current and proposed programs side-by-side.

<table>
<tr><th colspan="6">Current Program</th><th colspan="12">Proposed Program</th></tr>
<tr><td colspan="6">GIRs
17 Subjects</td><td colspan="12">GIRs
15 subjects</td></tr>
<tr><td colspan="6">Science Core
6 subjects (72 units)</td><td colspan="12">SMC Core
7 subjects (72 units)</td></tr>
<tr><td>Calc I</td><td>Calc II</td><td>Phys I</td><td>Phys II</td><td>Chem</td><td>Bio</td><td colspan="12">Common Foundations
3 Subjects (36 units)</td></tr>
<tr><td colspan="6">REST & Institute Lab
3 subjects</td><td colspan="4">Calc I</td><td colspan="4">Calc II + Lin. Alg.</td><td colspan="4">Physics</td></tr>
<tr><td colspan="2" rowspan="2">REST I</td><td colspan="2" rowspan="2">REST II</td><td colspan="2" rowspan="2">Lab</td><td colspan="12">Flexible Foundations
4 subjects, 1 from each category; at least 36 units of credit</td></tr>
<tr><td colspan="3">Chem</td><td colspan="3">Bio</td><td colspan="3">Comp</td><td colspan="3">PSM</td></tr>
</table>

<table>
<tr><th colspan="3">HASS
8 Subjects, including 2 CI</th><th colspan="3">HASS
8 subjects, including 2 CI and 1 Moral & Civic Perspectives</th></tr>
<tr><td colspan="3">Distribution Subjects
3 subjects, 1 from each category</td><td colspan="3">Distribution Subjects
3 subjects, 1 from each category</td></tr>
<tr><td>Humanities</td><td>Arts</td><td>Social Sciences</td><td>Humanities</td><td>Arts</td><td>Social Sciences</td></tr>
<tr><td colspan="3">Concentration Subjects
3-4 subjects</td><td colspan="3">Concentration Subjects
3-4 subjects, including at least 1 upper-level subject</td></tr>
<tr><td colspan="3">Elective Subjects
1-2 subjects</td><td colspan="3">Elective Subjects
1-2 subjects</td></tr>
<tr><td colspan="3" rowspan="2">Communication-Intensive (CI-H/HW, CI-M)
4 subjects, 2 in HASS, 2 in major</td><td colspan="3">Teamwork Intensive Requirement
1 subject, may overlap with major or GIRs</td></tr>
<tr><td colspan="3">Communication-Intensive (CI-H/HW, CI-M)
4 subjects, 2 in HASS, 2 in major</td></tr>
<tr><td colspan="3">Physical Education & Wellness Requirement
8 PE+W points plus swim requirement</td><td colspan="3">Physical Education & Wellness Requirement
8 PE+W points plus swim requirement</td></tr>
<tr><td colspan="3">Major</td><td colspan="3">Major</td></tr>
<tr><td colspan="3">Up to 12.5 additional subjects, including 2 CI-M, + up to 3 specified GIRs</td><td colspan="3">Up to 14.5 additional subjects, including 2 CI-M, or up to 15.5 subjects if at least 1 subject satisfies a GIR other than CI-M. In addition, majors may specify up to 2 Flex Foundations topics that students must take as 12-unit subjects.</td></tr>
</table>

This new set of required subjects incorporates subjects that already serve as foundations for most fields of study at MIT. We emphasize that students should learn the core concepts from each foundational SMC field in their first 5 semesters, which motivates our addition of a pacing requirement. We highlight some key features of the new GIR curriculum we propose:

- Our new set of subjects includes **1) computing**, and **2) probability, statistics, and machine learning**, which will enable students to navigate the data-rich world we live in, including the creative application of technology for discovery and providing the possibility of learning the underlying mechanisms behind phenomena in the natural world, as well as the function of modern AI tools that many of our students will develop and wield.

- We propose incorporating linear algebra into the second **math subject**, which enables follow-on classes to build on this ever-more-prevalent subfield of mathematics.

- We are excited by the ability to re-envision what a **physics** foundation should look like for scientists and engineers, and emphasize the importance of integrating disciplines.

- We propose that the **REST and Institute Lab requirements** be eliminated, with 24 units returned to the majors. Increasing the allowable size of majors to 11-14.5 classes (from the current 11-12.5) while allowing 12 units of GIRs to be specified by the major ensures that majors can adapt successfully to the new guidelines.

- We propose a **HASS requiremen**t that will continue to require eight HASS subjects with the same distribution and concentration requirements. In addition, we propose adding a requirement that at least one of the eight required HASS subjects is certified as a **Moral and Civic Perspectives subject**. This new certification addresses the desire by many in the MIT community to provide students with frameworks for understanding how ideas about values, ethics, and responsibility emerge from and transform the contexts in which they are embedded, how to align their individual and collective values with their actions, and how to make decisions in society.

- We propose incorporating a new type of requirement focused on **teamwork**, an essential skill regardless of a student's future trajectory. Many students already work in teams in some of their classes, but we believe that teamwork *practices* need to be explicitly taught alongside the teamwork itself.

- We also propose a new system for labeling and tracking subjects and programs that involve **experiential learning and hands-on "making and breaking,"** highlighting these educational experiences that embody the "manus" in "mens et manus." While this would not be a requirement, a label would serve to celebrate those opportunities and help students and advisors find them.

- To encourage students to build mentoring relationships with faculty in their classes, UROPs, and elsewhere, we propose a light-weight centralized process for students to solicit brief **letters of recommendation** throughout their time at MIT.

- Finally, we propose to broaden the **communications requirement** to incorporate visual communication and communications to non-experts (critical in today's environment), and to undertake experiments to understand how to best incorporate generative AI tools into these classes.

Aligning our policies and practices with our aspirations

Some of our overarching goals emerging from the task force are to better align our policies and practices with aspirations towards:

1. <u>Clarity</u>: Increase transparency and reduce complexity whenever possible.
2. <u>Commitment</u>: Refocus the classroom environment on high-quality in-person learning.
3. <u>Compassion</u>: Reduce unnecessary stress for students, instructors, and advisors.

The curriculum described above provides more freedom and choice to students, partially improving this alignment, but we realized that a wide range of policies currently interact to obstruct those goals. We thus propose the following set of policies:

1. Clarity
    a. Abolish the guidelines limiting overlaps between majors and GIRs
    b. Require that syllabi be posted publicly (or at least visible to all MIT users)
    c. Require interim grade reports one week before Drop Date
    d. Simplifying forms and procedures for Add, Drop, and Limited Enrollment
2. Commitment
    a. Study the trade-offs of eliminating pre-registration and moving registration to the second half of the prior semester
    b. Reduce scheduling conflicts and limit double-booking
    c. Reset classroom norms for all subjects, and pilot stronger norms for subjects that choose to be "Engaged Classrooms":
        i. In all subjects:
            1. Instructors begin and end class on MIT time
            2. The default for all classes is to be screen-free unless the instructor says otherwise and notes it on the syllabus
        ii. In "Engaged Classroom" subjects, all of the above plus:
            1. Students attend all classes, arrive on time, and stay for the entire class
            2. Default is screen-free except for explicit class activity
            3. Instructors adopt and certify pedagogical practices that ensure that attending class in person is valuable
3. Compassion
    a. Add a class day on the current fall Registration Day and remove a class day on the Wednesday before Thanksgiving
    b. Prohibit setting assignment due dates on holidays, the day before or after Thanksgiving break, or the day after spring break
    c. Shift the "last test date" earlier in the spring semester to better align with the fall

High-quality in-person learning, essential to our residential campus experience, relies on effective pedagogy. We thus propose a 5-year effort to broaden the adoption of improved pedagogy across campus, starting first with the new and revised GIRs, led by our Teaching and Learning Laboratory (TLL) and the Open Learning Residential Education Team (OL-Res). This effort would help incorporate best pedagogical practices into our new and revised GIRs and then support those practices during the teaching of the subjects, in a process that we hope would then expand outward.

Adapting to the future

Task forces such as ours are intense exercises in part because they only occur every 20-30 years. We believe that MIT should be assessing and adapting its curriculum carefully but continuously. Additionally, we anticipate that the next decade will be especially dynamic, as AI transforms some aspects of education. To enable us to adapt to the future, we propose a new governance structure for many of the MIT undergraduate requirements:

- A Committee on the Undergraduate Program (CUP) and a Committee on Curricula (COC) tasked and resourced with engaging more fully with their existing mandates and also empowered to support Institute-wide educational innovation;
- A set of new subcommittees of the CUP:
    - Ad Hoc Subcommittee on the Science, Math, and Computing Requirements (SSMCR), to potentially become a permanent subcommittee of CUP after 2-3 years
    - Ad Hoc Subcommittee on the Probability, Statistics, and Machine Learning requirement (SPSMR), to potentially become a permanent subcommittee or be absorbed into SSMCR
    - Ad Hoc Subcommittee on Teamwork Requirement (STR), to potentially become a permanent subcommittee of CUP after 2-3 years
    - Ad Hoc Subcommittee on the Moral and Civic Perspectives Requirement (SMCP), to potentially become a permanent subcommittee or be absorbed into SHR
    - These new subcommittees join the existing Subcommittee on the Communications Requirement (SOCR) and Subcommittee on the HASS Requirement (SHR)

We also propose the commissioning of two task forces:

- Task Force on Grading – grading emerged as a key element of the educational experience, with many community members advocating for reform, but this was beyond the scope of TFUAP. We recommend that this be taken up further.
- Task Force on AI in Teaching and Learning – new AI tools are emerging all the time, and MIT needs a dedicated group to develop strategies and tactics around their incorporation

Our proposed requirements above are a substantial change, but there is an opportunity to further experiment with our undergraduate program. One thing we learned through this process is that on many questions of interest, we thus do not have the relevant data. We thus recommend that the Institute also undertake an experiment in broad curricular flexibility, allowing a subset of the incoming class to choose to complete a subset of SMC, HASS, and major requirements to earn their degrees.

1: Background & Context

1A: History of the Science General Institute Requirements

The Silbey report provides an excellent history of the Science core requirements over time, providing context for how we arrived at the current system. We direct interested readers to pages 39 through 44 and summarize the relevant aspects here, adding material to bring us to the current date.

Before 1962, MIT's Science Requirement was rigid: four semesters of physics, four of mathematics, and two of chemistry. However, as student backgrounds diversified and high-school curricula changed, the 1962 Zacharias Committee, led by Jerrold Zacharias, was convened to reassess the undergraduate curriculum. The committee's 1965 reforms reduced the prescribed science core by half—to two semesters of physics, two of math, and one of chemistry—and introduced laboratory (one) and science-area (three) electives. The Institute Laboratory Requirement emerged from this reform, emphasizing problem-solving experience rather than rote lab exercises, encouraging students to think and work like professionals.

The science-area electives (which are now called the Restricted Electives in Science and Technology (REST) requirement) were intended to give students exposure to diverse scientific fields without enforcing uniformity. Originally, students chose one subject from each of six categories—life sciences, chemistry, mathematics, physics, earth sciences, and applied science, and a 6-unit engineering elective for non-ROTC students (this last elective was not pursued). This approach was simplified during implementation into the Science Distribution Requirement, in which students selected three subjects from different departments and fields. While this change added flexibility, it also created overlap between general education and departmental requirements; departments might require certain classes from those lists for their majors. Ultimately, departments were allowed to specify two of the four elective subjects in the Science Requirement. Thus, although subsequent curricular reform committees have debated the question of whether the GIRs could be tailored for different majors, MIT has, in fact, already allowed this for many decades.

Shortly after the implementation of the Zacharias reforms, the Chemistry requirement was broadened in 1969-70 AY from strictly 5.01 (Chemistry) to a set of options that included 3.091 (Chemistry of the Solid State), 5.41T (Introduction to Structure, Bonding, and Mechanism), or 5.60 (Chemical Equilibrium). Two years later, 7.01 was added as a fifth option in 1971-72 AY. Biology was allowed as an option until the 1985-86 AY, when the list of classes was tightened to allow only 3.091 or 5.11. In the late 1980s, an experimental subject combining chemistry and biology (SP.01) was an allowed option.

In the early 1990s, Biology (7.01x) was added back into the GIRs as a separate requirement by reducing the number of Science Distribution requirements to two subjects (which is also when they were formally renamed to the REST requirements).

In the intervening years, the REST and Institute Lab requirements were almost entirely co-opted by the majors. Of the 58 undergraduate majors analyzed by TFUAP, 36 majors count 24 units of REST in their degree programs, and 5 additional majors include 12 units; this accounts for all Engineering majors and all Science majors but one (Course 18). Additionally, all Engineering and Science majors (again, except for Course 18) use 12 units of Institute Lab in their degree programs.

In late 2003, a Task Force was again charged with reviewing MIT's undergraduate education. Chaired by Robert Silbey, the task force worked for 2½ years "to address the goals, content, and structure of MIT's undergraduate education." The Silbey Task Force concluded that while the existing core prepared students well for traditional disciplines, it fell short of the breadth and creative capacity needed to bridge fields and lead emerging, hybrid areas of science and engineering. The Task Force instead proposed an eight-subject Science, Mathematics, and Engineering (SME) Requirement, with a set of three Required Subjects (Mechanics, Single-Variable Calculus, Multi-Variable Calculus) and then a flexible choice of five of six Foundational Subjects across Chemical Sciences, Computation & Engineering, Life Sciences, Mathematics, Physical Sciences, and Project-based Experience.

The Task Force's report and recommendations were released in October 2006 and were then reviewed in a variety of forums in the 2006-7 AY. In October 2007, the Committee on the Undergraduate Program (CUP) charged a Subcommittee on the Educational Commons that worked for an additional year to refine the recommendations. Their report, released in November 2008, reformulated the Silbey recommendations for the Science core to an eight-subject SME requirement encompassing one semester each of Single-Variable Calculus, Multi-variable Calculus, Classical Mechanics, Electricity and Magnetism, Chemistry, Biology, and two new types of classes: SME Foundations and Elements of Design. Each of the 6 specified required subjects would be offered in various flavors (akin to the 7.01x subjects). SME Foundations would "provide introductions to fundamental topics and/or modes of analysis that are broadly applicable in science, mathematics, and engineering," such as "differential equations, probability, statistics, discrete math, linear algebra, and computation." These would be allowed to be specified by the departmental programs. Elements of Design would "capture modes of reasoning that facilitate design" and "that build the core modes of reasoning in the context of authentic problems from fields across the Institute." There would be multiple flavors of this requirement.

The proposed revision to the Science core ultimately failed in a faculty vote in 2009 for a variety of reasons. Some faculty thought the reforms were not radical enough, while others were concerned about the "flavors" of the Science Core.

In 2016, Chair of the Faculty Krishna Rajagopal and Dean for Undergraduate Education Denny Freeman charged a working group, chaired by Professor Eric Grimson, to examine the role of "algorithmic reasoning/computational thinking" in MIT's undergraduate education. The working group ultimately proposed that "computational thinking should play an explicit role in the formal education of all undergraduate students at MIT." CUP then took up the report and proposed two approaches for incorporating a computational requirement into the GIRs: reducing the REST requirement by one subject in order to add a 12-unit computing GIR, or keeping the REST as-is and adding a 6+6 unit computing GIR to the set of Science GIR requirements, where 6 units would be introductory from a list of approved subjects, and the 6 units would follow-on as mandated by departmental programs. Ultimately, however, this Computational Thinking GIR did not appear to have enough support among the faculty to proceed.

In 2019, then Chair of the Faculty Professor Rick Danheiser convened an Ad Hoc Working Group on the SME Requirements. This effort was then followed by the Undergraduate Program Refinement and Implementation Committee (also chaired by Rick Danheiser) as part of the COVID-era Task Force 2021 and Beyond. That committee outlined the process that led to TFUAP's creation, noting that this effort had already been postponed due to the focused response to the COVID-19 pandemic.

1B: History of the Humanities, Arts, and Social Sciences General Institute Requirements

As with the science requirements, the Silbey report provides an excellent history of the HASS core requirements over time. We direct interested readers to pages 64 through 68 of that report, summarize relevant aspects here, and add a brief account of the changes since the Silbey report was published.

From the outset, MIT's founders rejected a purely classical education and sought leaders fluent in modern science and civic life. Mid-century reforms led by the Lewis Committee accelerated this aim: MIT created a *School* of Humanities and Social Sciences, which was followed in 1951 by a highly structured, eight-subject HASS requirement anchored by a four-term paced Western civilization sequence and an upper-division "concentration." That tight core changed within a decade as MIT admitted more broadly prepared students—many with AP credit—and as newly strengthened, research-active social science faculties drew students toward advanced topics earlier.

A 1964 adjustment added limited flexibility, but there were still hundreds of students each year requesting exceptions to the core, prompting a 1974 overhaul that replaced the lower-division core with a distribution system spread across fifteen categories ("Hum-Ds"), retained concentrations, and added room for free HASS electives. The 1974 model proved too loose: advisors saw aimless course-picking, so in 1988–89 the faculty sharply tightened the system—reducing distribution categories to 5, and dramatically culling the number of approved subjects, imposing baseline writing and class-size expectations, and rebranding the list as HASS-D. Around the same time, HASS minors were introduced and widely adopted, and in 2000, the Communication Requirement addressed concerns about graduates' writing and speaking skills by requiring two communication-intensive HASS subjects (as part of an overall four-subject CI requirement), typically in the first two years. That overlap advanced important goals without expanding the GIRs, but it also made navigation harder and sometimes pitted the aims of distribution (breadth) against those of communication intensity (writing practice).

The Silbey report recommended restructuring the HASS into two major parts: a foundational phase and a concentration phase. The foundational phase would consist of four subjects—expository writing and three "foundational electives" distributed across the categories of the arts (A), the humanities (H), and the social sciences (SS). A three- or four-subject concentration would be sponsored by a particular department or interdisciplinary field. A set of First-Year Experience subjects would be specifically created to cater to first-year students, and all students would be required to take one of these subjects as part of their foundational electives.

After the report's release, the Committee on the Undergraduate Program (CUP) charged a Subcommittee on the Educational Commons that worked for an additional year to refine the recommendations. They adjusted the distribution requirement to require one class across each of the H, A, and SS categories, leaving a free HASS elective subject as the eighth HASS requirement. The committee also proposed that the first-year subjects be optional. This proposal was adopted by the faculty in 2009, and the newly created Subcommittee on the HASS Requirement (SHR) was tasked with defining and evaluating the optional first-year subjects, which were eventually renamed HASS Exploration (HEX) subjects. These subjects are meant to be small, team-taught classes that explore a major concept or topic from multiple viewpoints across the humanities, arts, and social sciences. They can count towards the HASS Distribution (if applicable) or as a HASS Elective. SHR produced an interim report in 2011 and a final report in 2014, ultimately recommending that HEX subjects remain optional rather than required elements of the HASS curriculum. Since 2014, the number of HEX subjects has declined, with very few HEX subjects continuing to be offered each year.

1C: MIT's Legacy of Educational Innovation

From its founding more than 150 years ago, MIT has spearheaded numerous educational efforts that have been copied around the globe, constantly focusing on new ways to bring the spirit of "mens et manus" to life both on campus and beyond.

Three of the most beloved educational innovations that have come to define an MIT education over the past fifty years are UROP, IAP, and first-year learning communities, established in 1969, 1971, and 1969, respectively. While undergraduate students had worked on faculty research before then, the creation of UROP represented one of the first formal programs recognizing this practice. The formula for a UROP has not changed: projects must have educational value for the student and the approval of an MIT faculty member or other approved researcher, but the program has exploded in size, with 93% of undergraduates now participating at least once. Undergraduate research has similarly been formalized at countless research universities, with many citing MIT's program as a model and several adopting the same name.[2] IAP, meanwhile, was established with several goals in mind, including both practical concerns associated with the prior practice of ending the fall term in January and pedagogical aspirations of creating a time for more flexible, leisurely, and independent approaches to learning, teaching, and research.[3] The first first-year learning community, the Experimental Study Group (ESG) was established in Fall 1969 to encourage active student involvement, independent work, and communication. ESG offers classes that cover the SME GIRs as well as several HASS options. A year later, Concourse established a cooperative curriculum between science, humanities, and engineering. Terrascope was founded in 2002 to "foster and facilitate multidisciplinary research and education efforts in earth and environmental sciences." Most recently, Design Plus was created in 2021 to provide a first-year community focused on design and making. In an alternative to the conventional large classroom experience, these first-year learning communities are valuable cohort-building experiences that facilitate collaborative learning and higher levels of student-instructor interactions.

More recent examples of MIT's educational innovation have focused on using technology to democratize and amplify learning. In 2001, MIT announced OpenCourseWare (OCW), which would allow anyone with an internet connection to access MIT's syllabi, lecture notes, exams, and video lectures at no cost. Since its launch, OCW has reached hundreds of millions of learners from all parts of the world, including many who go on to pursue a degree at MIT. This bold move by MIT helped catalyze the Open Educational Resource (OER) movement, which aims to democratize access to high-quality educational materials.[4]

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[2] MIT Undergraduate Research Opportunities Program Strategic Plan Summer 2025

[3] The Independent Activities Period (IAP) Subcommittee of the Faculty Policy Committee

[4] About Us | MIT OpenCourseWare | Free Online Course Materials

Auditing Classes at M.I.T., on the Web and Free

By CAREY GOLDBERG

CAMBRIDGE, Mass., April 3 — Other universities may be striving to market their courses to the Internet masses in hopes of dot-com wealth. But the Massachusetts Institute of Technology has chosen the opposite path: to post virtually all its course materials on the Web, free to everybody.

M.I.T. plans on Wednesday to announce a 10-year initiative, apparently the biggest of its kind, that intends to create public Web sites for almost all of its 2,000 courses and to post materials like lecture notes, problem sets, syllabuses, exams, simulations, even video lectures. Professors' participation will be voluntary, but the university is committing itself to post sites for all its courses, at a cost of up to $100 million.

Visitors will not earn college credits.

The giveaway idea, President Charles M. Vest of M.I.T. said, came in a "traditional Eureka moment" as the institute — like nearly every other university — brainstormed and soul-searched about how best to take advantage of the Internet.

Called OpenCourseWare, the initiative found broad resonance among the faculty members, said Steven Lerman, the faculty chairman.

"Selling content for profit, or trying in some ways to commercialize one of the core intellectual activities of the university," Professor Lerman said, "seemed less attractive to people at a deep level than finding ways to disseminate it as broadly as possible."

Universities have been flocking into "distance learning" — offering courses online to off-campus paying students — and commercial ven-

Continued on Page A16

Excerpt from New York Times article published April 4, 2001, by Carey Goldberg

For on-campus learners, one of the most impactful changes in recent decades was the adoption of Technology Enabled Active Learning (TEAL) in the physics GIRs. The shift from the traditional model of lectures and recitations was spearheaded by Professor John Belcher in 2000, responding to the nationwide pedagogical trends in the late 1990s and a desire to improve attendance and reduce failure rates in introductory physics. The TEAL model, now standard across the physics GIRs, relies on in-class problem-solving, small group work, and a large teaching team that can provide immediate feedback on students' work. After succeeding in bringing down failure rates, MIT's Department of Physics has continued to iterate on the TEAL model, responding to student feedback, changing technology, and increasing understanding of how students learn best. The model has been adopted in other schools as well. Yale cites MIT's model as the inspiration for their TEAL classrooms.[5]

1D: Why now?

The world is changing, and the pace of change is increasing. We need an education that is more responsive to these changes and able to adjust to future ones. We owe it to our students to engage them in deep learning that takes advantage of the best of a residential college experience and current best practices in education.

Higher education faces a crisis of confidence in the public, but MIT continues to be well-regarded. This gives us an even greater responsibility to remain at the forefront of innovation in higher education. Given MIT's legacy of educational innovation and leadership, we are particularly well-equipped to pursue opportunities to improve students' ability to achieve the learning and process goals that we heard from the community at the beginning of our process. This involves not

[5] TEAL at Yale | Poorvu Center for Teaching and Learning

just the GIRs, but other avenues by which our students learn, and their classroom experiences over the course of their MIT career.

Students (and everyone else) are being bombarded with demands and have more distractions than past generations. A residential education at MIT must prepare students to engage with the world. MIT must therefore think carefully about the residential educational experiences and structures that are conducive to learning and experience, and allow students to focus on cultivating the sense of wonder and curiosity that fuels learning, exploration, and engagement.

Some of the most interesting questions and global grand challenges involve intersections between disciplines. And yet the majority of classes, including GIRs, involve teaching that is mono-disciplinary. The students who will arrive on campus in the next few years deserve a cross-cutting education that highlights the best of MIT, the interdisciplinary creativity and collaborativeness of our scientists, engineers, humanists, artists, designers, and innovators, who work tirelessly to advance human knowledge and create a better world.

The last substantial change to the structure of the Science GIRs occurred in 1965, more than 60 years ago. Since then, besides the relatively straightforward exchange of Biology for a REST class, no other programmatic changes have occurred, despite multiple efforts to update the requirements. However, our world now differs dramatically from 1965.

To its credit, the MIT community has adapted within this fixed GIR framework: instructors have modernized pedagogy (TEAL in physics, "goodie bags" in 3.091, and interdisciplinary teaching in 21.01), course content has tracked breakthroughs (CRISPR in biology, incorporation of some linear algebra topics into 18.02), and students increasingly treat computation as essential preparation for many majors and as a vital skill for 21st century scientists, engineers, humanists, designers, and artists.

As we enter the second quarter of the 21st century, we need a program that can more nimbly adapt to the accelerating pace of change across nearly all aspects of education, research, and society. *MIT's continued leadership as the premier institution of science and technology requires us to lead in this moment.*

As TFUAP engaged the community, formulated a set of learning and process goals, collected white papers, met one-on-one with relevant stakeholders, and worked to design a new undergraduate academic program, new crises and opportunities emerged that have made the future increasingly murky. To name just two, the rise of generative AI and the implications of recent federal policies on MIT's budget have demanded enormous amounts of faculty energy and an ever-evolving response. While some have questioned the prudence of engaging in a large-scale curriculum revision process in these conditions, TFUAP notes that the changes to curriculum and curricular flexibility, robust governance, and the interdisciplinary focus of our recommendations will serve us well in the uncertain times ahead. Inaction now would result in MIT missing a critical opportunity to address the growing convergence between disciplines, including, but not limited to, computing and generative AI.

1E: What might an MIT education look like in ten years?

No group of faculty members can predict the future, but having studied the past and present and thought deeply about what we want for future MIT graduates, TFUAP has developed a vision for the MIT of 2036.

When envisioning the learning experiences to inspire and challenge our students and best prepare them for purposeful and fulfilling lives and careers, we prioritized:

1. A wide breadth of disciplines in which students can develop essential literacies—adding computing; probability, statistics, and machine learning; moral and civic perspectives; and teamwork to its rich core.
2. Exposure to and engagement with a broad range of disciplines and disciplinary thinking within their first 5 semesters.
3. Academic and intellectual growth and inspiration in an educational environment that promotes their well-being by providing space and time for deep learning and reflection.
4. Deep and meaningful student engagement with peers and instructors in learning environments across the institute, leveraging the unique and transformative affordances of in-person, residential education.
5. Experiences that allow students to see connections among fields, and to engage with and innovate in these fertile multidisciplinary spaces.
6. MIT students need to be those who understand fundamental principles in a breadth of fields so that they can apply knowledge and different creative ways of thinking in their professional and personal lives.

In our imagined future, students will develop disciplinary knowledge, critical reading and thinking skills, the ability to communicate and collaborate within and across disciplines, facility with the latest technical tools for accessing and processing information, and the ability and motivation to critically evaluate the costs and benefits of those tools. Building on core knowledge in science, math, computing, humanities, arts, and social sciences, students will explore the frontiers of thought with a sense of wonder, working closely with faculty on a variety of scholarly pursuits in labs, centers, libraries, research sites, museums, performance spaces, and in the community, at MIT and beyond.

Their data literacy and familiarity with not only the use of vanguard technologies, but also the workings and impacts of these technologies, will enable them to question the many claims they encounter and carefully untangle facts from fiction. Their rigorous study of the humanities, arts, and social sciences will build their understanding of themselves and society, encouraging and enabling them to solve problems more ethically and effectively.

Knowing that every MIT student has studied computation, science, probability, statistics, and machine learning will enable classes across the institute to leverage the latest tools and rigorous technical methods for solving problems. By delegating basic calculations and other mechanical tasks to machines, instructors and students alike will spend more time on creative, complex, and interpersonal pursuits. As MIT doubles down on our collaborative learning environment through a new Moral and Civic Perspectives requirement and new teamwork-intensive classes, students will learn to work more effectively and across differences with their peers.

We envision that faculty will embrace this new spirit of collaboration: serving together on task forces and subcommittees that oversee innovation and improvements across the GIRs; guiding MIT's evolving response to AI; and crafting new grading practices and policies that effectively and accurately evaluate student learning.

As described in Section 4, instructors involved in GIRs will benefit from a variety of formal and informal opportunities to collaborate with their colleagues to share research-based best practices and to leverage technical and interpersonal connections across disciplines. These interactions will enrich instructors' teaching experiences while supporting deep and enduring student learning and understanding.

Even in this dynamic environment, other experiments with pedagogy, curriculum, and policy will be ongoing.

Guided by our shared values and learning goals, we will adopt an MIT approach, relying on ongoing discussions of undergraduate programs and learning experiences: leveraging innovative ideas; collaboration across disciplines and roles; and data-informed decision-making. As highlighted in the Executive Summary and described throughout our report, we propose structures and processes to ensure that the MIT undergraduate experience can more nimbly adapt to future opportunities and challenges while remaining true to our mission and values.

For a full distillation of our community listening, including a complete description of what TFUAP believes every MIT graduate should know or be able to do, see TFUAP's Phase 1 report.

2: Curriculum

In designing a new set of General Institute Requirements for undergraduates, TFUAP relied first and foremost on our set of learning and process goals developed in Phase 1. These are fully described in our Phase 1 report and listed in Appendix B, so we will not repeat them here. In short, these goals sum up the things we think every MIT graduate should be, know, and be able to do, plus a few qualities that should characterize their education while they are here. Some of these goals are unique to MIT, while many could be viewed as equally appropriate at any of our peer schools. The combination of all of them, marrying STEM and HASS, mind and hand, represents both the best of what MIT education is and has been, and what we and many in the community believe it could become.

Underlying the whole set of goals is a core tension between competing aims: 1) teaching a growing list of foundational areas needed by MIT graduates; and 2) providing time, space, and structure to enable the sense of 'play' and creativity that fuels our amazing students and reduces feelings of overwhelm. It is impossible to achieve both aims without rethinking the structure and content of existing requirements, but TFUAP also felt strongly that each discipline within the current GIRs is an essential field that students should encounter in the first 5 semesters of their MIT careers. The recommendations below represent our best attempt to reconcile these aims.

2A: Science, Math, and Computing GIRs (SMC)

The three goals of the GIRs described at the start of our report were reinforced by a Foundational Working Group on the SME GIRs, which studied the existing science core subjects and provided a report to TFUAP to inform our work. TFUAP agrees that these three goals describe well the functions of both the current science core and the proposed SMC GIRs and that the departments stewarding these subjects are delivering high-quality learning experiences to our students.

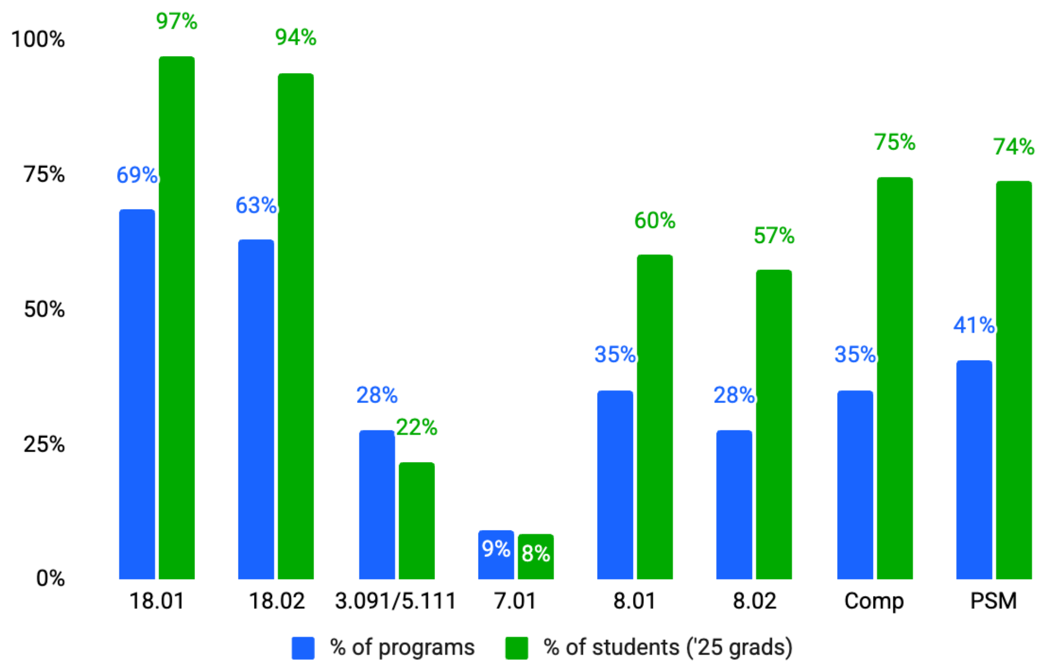
Beyond these three goals, we add two additional ones, informed by our listening tour and internal deliberations over the past year-and-a-half:

4. Cohort-building experience – the GIRs serve an important function as a cohort experience, welcoming students to MIT's academic community and allowing them to get to know their peers.
5. Leadership – our GIRs communicate to our students, employers, peer institutions, and K-12 schools what MIT considers critical to a science and engineering education.

Importantly, however, most of the GIR subjects serve some, but not all, of these functions, and some functions vary depending on the student's eventual major (Figure 3).

Figure 3

SMC Subjects Required by Primary Major



**Subjects were classified as "required" if listed as a prerequisite for at least one required subject (for current GIRs) or if at least 6 units of applicable content[6] were included in major requirements (for proposed Computation and Probability, Statistics, and Machine Learning GIRs). Student counts are based on primary majors of the graduating class of 2025. Actual numbers of students who require each subject are likely higher due to second majors, minors, and pre-health requirements.*

In addition to the existing science core areas of calculus of single and multiple variables, physics (specifically mechanics and electricity and magnetism), chemistry, and biology, our listening tour highlighted other areas of study that have emerged as critical to achieving these goals. These include computation, linear algebra, probability, statistics, and machine learning.

Noting that it is impossible to reasonably devote an entire class to each of the existing and new topics and still allow students to graduate in four years, it becomes necessary to address multiple topics within each 12-unit subject. This will require restructuring of some classes, but it maintains exposure to the core topics and ways of thinking within science, math, and computing that have long been deemed essential fields, while making space for the new foundational topics.

[6] Subjects with 6+ units of applicable computing content: 6.1000/6.100A, 1.00(0), 2.086
Subjects with 6+ units of applicable PSM content: 1.010A, 1.010B, 1.073, 1.074, 2.086 + 2.671, 6.100B, 6.C01, 6.3700, 6.3800, 6.3900, 9.07, 14.30, 15.069, 16.09, 16.C20J, 18.05, 18.600, CSE.C20J
Note that this was for preliminary analysis and does not mean that these subjects will count for the associated proposed GIR.

Why not "choose X from a list of Y"?

When faced with the problem of more topics to cover than subjects in which to cover them, it is natural to consider leaving the choice to students by giving them a list of Y classes (where Y > 6) and asking them to choose X (where X = 6 or whatever you deem the maximum number of subjects to require). This is the way many of our peer institutions function. TFUAP considered this possibility but ruled it out because it goes against the stated goals of the GIRs. If we consider these fields "foundational" and "essential," how can we allow students to graduate without encountering them? We also worried that such a system could create a "race to the bottom" where students selected classes based on a rational but unhealthy impulse to take classes with the lowest reported workload and highest average grades.

Fundamentals for All, Building Blocks for Some

Every topic we listed represents some combination of goals of the GIRs, namely: "foundational building blocks," "literacy in essential fields," and "methods for creative analytical thinking" that we deemed necessary for every MIT graduate, but some of the topics are foundational building blocks for some, but not all students. For example, the biology and chemistry GIRs are, for many MIT students, the only biology and chemistry-related subjects they take in college. These subjects teach these students literacy and methods for creative analytical thinking, but for this subset of students, they do not serve as foundational building blocks for more advanced coursework. Likewise, some students in the sciences and humanities might not need the same foundational building blocks in computing and/or PSM as their colleagues in engineering, but such subjects serve to teach these students literacy and different methods for creative analytical thinking. In our current system, all students would take the same classes regardless of future major and end up using the vast majority of their precious time at MIT fulfilling requirements rather than having the flexibility to explore possible directions of study and the time to deeply engage with their studies.

In our proposed SMC GIR plan, outlined below (Table 1), students could opt to take one "integrated GIR" which would cover the aspects of two interconnected fields that the faculty feel every MIT graduate should know, or, alternatively, two 6-unit single-discipline 'exposure' subjects (preferably taught as full-semester courses, not half-semester). In total, this would result in students taking at least 72 units of SMC GIR subjects. The specifics of these subjects can be found below. We are persuaded that, with the right teams, integrated classes could be significantly stronger than the sum of their parts, and we anticipate that "integrated GIRs" might incorporate other disciplines in the future, including eventually combining HASS and SMC. We encourage MIT to support, both financially and administratively, pilots of such classes.

Table 1

Topics covered in the proposed SMC core

Required Areas of Study	**Approaches to satisfy (total = 72-84 units)**

Calculus (Single variable + Multi-variable)	Sequence of 18.01 (single variable calculus, 12 units) and 18.02 (combined multi-variable + linear algebra, 12 units)
Linear Algebra	
Physics	New Physics I GIR (12 units) or Physics II GIR (12 units) for students with AP/ASE Physics I credit
Chemistry (6-unit, 12-unit options, + 12-unit integrated option)	Choose at least 36 Units worth of Chemistry, Biology, Computation, and PSM. All 4 subject categories are required, with a minimum of 2 12-unit subjects.
Biology (6-unit, 12-unit options, + 12-unit integrated option)	
Probability, Statistics, and Machine Learning (6-unit, 12-unit options, + 12-unit integrated option)	
Computing (6.100A (6 units), 6.1000 (12 units), integrated option (12 units))	

Pacing Requirement

Given the foundational nature of all the SMC GIRs, their role as cohort-building experiences for MIT students, their important function of exposing students to disciplinary breadth early on as they contemplate potential career paths, and their pedagogical approach that teaches learning habits students build on in subsequent coursework, TFUAP feels that it is important for students to take these subjects early in their time at MIT. While we expect that students will complete most SMC subjects in their first year, we aim to preserve some flexibility for students to explore majors, retake subjects as needed, and pursue electives in their first year. Therefore, we propose that students be required to complete 72 units of SMC GIRs by the end of their fifth semester at MIT (typically junior fall, but may be later for transfer students). We choose five semesters (updated from four semesters in the draft report) to balance competing needs: students want freedom to explore and so may desire to spread out their GIRs, whereas departments and instructors want to ensure that these subjects are taken early enough to have an impact. Five semesters to take 72 units seemed like a reasonable compromise.

While students would be allowed to spread their SMC GIRs out as they wish within these 5 semesters, TFUAP recommends that first-year advisors and UAC advisors work with students to develop a pacing plan that keeps them on track. Students who do not complete their SMC GIRs by the end of their fifth semester would be reviewed by the Committee on Academic Progress and may be put on an SMC requirement warning similar to the existing Communication Requirement Warning, which includes a credit limit.

Incoming Credit for SMC Subjects

Many students earn credit for MIT's current science core subjects through AP or other exams taken before arrival, through advanced standing exams (ASEs) offered at MIT, or through transfer credit from another university. Collectively, we will refer to these mechanisms as "incoming credit." Each mechanism for earning incoming credit is meant to indicate that a student has a level of preparation comparable to what they would have if they had taken the corresponding MIT subject. Determining which mechanisms achieve this standard, and designing ASEs, is left to the individual departments awarding credit.

When the incoming credit mechanisms are well-aligned with the corresponding subjects, there are many benefits to students and faculty, such as preventing advanced students from feeling bored and frustrated repeating familiar material, protecting less-prepared students from being compared to overly advanced peers, and reducing the instructional burden of teaching larger classes with more variation in preparation. However, poor alignment between incoming credit mechanisms and corresponding subjects can result in students missing foundational learning outcomes and being unprepared for subsequent coursework.

Balancing these considerations and ensuring that mechanisms for awarding credit are well-calibrated is an ongoing challenge, and one that TFUAP feels departments should take the time to revisit. As MIT goes through the exercise of redefining the learning outcomes of each SMC GIR, TFUAP recommends that departments, in consultation with CUAFA and the SMC and PSM subcommittees described later, undergo a process to assess how MIT awards incoming credit. These processes should involve reviewing relevant AP/IB and other international assessments and scoring criteria, reviewing and potentially redesigning ASEs, and outlining clear transfer policies and processes. In cases where multiple departments offer a particular GIR, this process should involve all relevant stakeholders, but the decision whether to award credit under a particular course number should remain up to the offering department.

Calculus I

TFUAP believes that given the fundamental nature of single-variable calculus (see Figure 3) and the close mapping of 18.01 topics to those currently taught in AP Calculus BC (which most incoming students use to satisfy this GIR), the 18.01 requirement should remain unchanged. Continued attention should be paid to ensuring that 18.01 and 18.01A are taught effectively so that all MIT students can build a solid foundation in calculus early in their time at MIT, regardless of the opportunities available to them in high school. The suggestion has been made to eliminate 18.01 as a requirement, given that a large fraction of students place out of it. However, discussions with MITFLI, CUAFA, our student members, and many other stakeholders brought up that the students who need to take 18.01 are disproportionately from disadvantaged backgrounds, and that replacing 18.01 with other requirements or forcing completion of 18.01 in the summer before they join MIT would negatively impact these students.

Calculus II & Linear Algebra

Rationale

Historically, 18.02 has been almost exclusively a subject on calculus that focuses on the big integral theorems that closely tie to 8.02, with an emphasis on two and three dimensions (the "physical" ones). In recent years, 18.02 has slowly evolved, introducing more linear algebra and de-emphasizing integration. This shift reflects the increasing role of linear algebra across the curriculum, as well as advances in computing that make it easy to compute integrals that once would have been daunting. The shift was also meant to avoid duplication of basic linear algebra that currently happens in 18.03 and 18.06. Finally, it also reflects the increasing importance of numerical modeling compared to classical continuous modeling using differential equations. These trends have only continued, and there is a strong argument to keep 18.02 as a GIR and further evolve it.

Requirement

TFUAP proposes that MIT continue to require a second math class, nominally 18.02, for all students, but that the content of 18.02 be revised to include linear algebra.

The current version of 18.02 has 3 distinct units:

1. Vectors, matrices, and basic linear algebra (new within the last few years)
    a. vectors: addition, scalar multiplication, and dot products
    b. matrices, determinants, and cross products
    c. lines, planes, and systems of linear equations
    d. eigenvalues and eigenvectors
2. Differential multivariable calculus
    a. parameterized curves, velocity and acceleration, polar coords
    b. functions of several variables, graphs, and level sets
    c. partial derivatives and gradients, tangent planes, and linear approximation
    d. optimization, first and second derivative tests, saddle points, least squares
    e. chain rule
    f. Lagrange multipliers and eigenvalues revisited
3. Integral calculus in several variables
    a. double and triple integrals
    b. change of variables and Jacobians
    c. polar, cylindrical, and spherical coordinates
    d. line integrals and Green’s theorem
    e. surface integrals and flux
    f. divergence theorem
    g. Stokes’ theorem
    h. conservative vector fields and potentials

At present, linear algebra comprises roughly two weeks of class time, and the other two units make up most of the class. The content in units 1 and 2 is widely applicable, both in the physical sciences and in computing and elsewhere. However, much of the content in unit 3 is more narrowly applicable to physics and some engineering disciplines, making it more appropriate in an introductory class serving those majors rather than all MIT students.

Some important topics that TFUAP believes should be expanded include:

- Work in large dimensions.
- Linear algebra, including subspaces, basis, and dimension, as well as more content on matrices, including rank, column space, and null space.
- Gradient descent and optimization.
- Convexity.

This expansion could be achieved by further reducing the integral calculus, though it would not be entirely eliminated. We provide Appendix G that includes a report from the Math Department on how 18.02 might evolve.

The content change to 18.02 will have downstream implications on 18.06 and subjects that need the removed integral calculus content.

Process, Timing, and Oversight

We anticipate that it will take one academic year to revise and pilot this new version of the class, and that work and resources will be needed to adjust the curricula of downstream math subjects. This revised calculus & linear algebra class, along with the single-variable calculus class, will be overseen by the new subcommittee on the SMC requirement described below.

Physics

Rationale

8.01 (Physics I, covering classical mechanics) and 8.02 (Physics II, covering electromagnetism) have served the MIT undergraduate student population since MIT's inception. (Before 1962, four physics subjects were required, but the requirement was reduced to two after the Zacharias report.) These subjects have been leaders in new pedagogy (i.e., TEAL) and a worldwide model for teaching general introductory physics. Within MIT, in addition to providing an introduction to some fundamental physics concepts, these subjects serve as a cohort-building experience, prepare students for a variety of degree programs, reinforce mathematical concepts taught in 18.01 (Single-variable calculus) and 18.02 (Multivariable calculus), and transition incoming students to the rigor of the MIT undergraduate experience.

These classes originally explicitly served “to provide a substantial foundation for subsequent engineering studies” (Lewis et al., p. 37), though in the past half-century their purpose was appropriately broadened (since many MIT students do not study engineering but they all have to take the physics GIR) to show “how mathematics and the natural sciences are intellectually intertwined and how reductive science can best be approached” (Silbey et al., p. 47) in the case of 8.01, to build students’ problem solving and critical thinking skills that are important across many areas of engineering and the sciences.

We note that the idea of reducing the number of required physics subjects to one was suggested by the Silbey commission, which recommended requiring 8.01 and providing 8.02 as an option for students to take. Almost twenty years later, we are motivated by a similar and even more urgent desire to incorporate new topics and ideas into the required core curriculum as we look to update and modernize MIT’s undergraduate curriculum. However, rather than simply choosing 8.01, we believe there is a long-term opportunity to devise a new introductory physics GIR subject.

Requirement

We propose a Physics GIR subject that evolves over three phases. In the initial phase, the Physics GIR subject will be 8.01 Mechanics. We chose this subject instead of 8.02 for a few reasons. First, mechanics is a subject for which students have natural intuition. Second, most students enter MIT having had mechanics taught in an algebraic context, easing the extension to college-level mechanics taught with calculus. Here, their natural intuition helps them when tackling new concepts and solving problems, as nonsensical answers are easier to identify. Third, 8.01 is widely applicable to a variety of majors: 19 degree programs, representing almost 700 students, require 8.01 for a follow-on course in their major.

In Phase 2, we propose that the Physics department, in consultation with downstream departments, develop a set of Physics II subjects that would build on 8.01 and bring the wide breadth of Physics to early undergraduate students. These subjects would include 8.02 Electricity and Magnetism (E&M), but subjects could also include aspects of Statistical Mechanics, Modern Physics, and other foundational topics (see Appendix H). We are excited about the possibility that the set of Physics II subjects will inspire our students to explore their interests.

Finally, in Phase 3, the Physics department would revise the main Physics GIR (8.01). There may be opportunities to incorporate topics, like E&M or modern physics, into the Physics I GIR. For example, mechanics and electromagnetism are two domains that process energy, coming together in electromechanical systems such as motors and generators. There are also opportunities to incorporate computation into the Physics GIR, much as Math is currently reinforced in 8.01. The subject can leverage the experience in ES.801 and ES.802, which introduced computational thinking assignments into the ESG versions of 8.01 and 8.02 (associated white paper).

Importantly, students who place out of Physics I using ASE or AP Credit, in any of these phases, would be required to take a Physics II subject to satisfy their Physics GIR. In this way, all MIT students would be exposed to Physics at the MIT level, taught by MIT faculty.

Process, Timing, and Oversight

We propose that at the outset (Phase 1), the Physics GIR be 8.01 and its variants, or 8.02 and its variants (for students who test out of Physics I), as those subjects currently exist. In Phases 2 and 3, the Physics department should seek broad input from the science and engineering community about content and pedagogy, but should ultimately aim to develop a set of coherent and rigorous subjects for the Physics II subjects and the revised Physics I subject.

Impact on 8.01 and 8.02

We anticipate minimal impact on 8.01 in Phase 1, though in the long term, the subject should evolve as noted above. 8.02 will decrease in size, though it is currently required by 15 departmental programs encompassing >650 students, and will serve as the GIR for students testing out of Physics I, and so the enrollment will still be substantial.

Impact on existing courses

A single Physics GIR subject will undoubtedly impact majors that rely on 8.02. Majors that depend on 8.02 will need to add that to their major requirements, or teach the required concepts in other subjects.

Flexible Foundations/Essential Literacy GIR Subjects

Rationale

MIT has an opportunity to lead by incorporating interdisciplinary courses into the fabric of its curricular DNA (the GIRs). Many real-world challenges require collaboration between fields. While MIT is expert at providing such instruction near the end of a student's undergraduate career (such as in capstone classes), and we have a history of experiments at the beginning of their career (e.g., the First-Year Learning Communities), we believe MIT should bring integrated curricular offerings to a broader audience of students at the outset of their undergraduate career.

We propose the development of a set of integrated subjects that would serve as GIRs. Integrated subjects would be intended to: 1) prepare students for a future defined by collaboration, creativity, and societal impact; 2) ensure all students, regardless of major, develop a holistic scientific and data literacy; 3) meet the needs of majors and nonmajors in these fields alike; and 4) establish curricular flexibility that enables new GIR course development and faculty collaboration. We propose that integrated offerings would provide a way for additional departments to contribute to the GIRs and provide students with different perspectives on these disciplines. For example, an integrated offering on chemistry and biology with input from Chemistry, DMSE, Biology, CEE, and

EAPS is an opportunity to bring climate change directly into the GIRs. Other combinations of disciplines could highlight interconnections between fields that will further differentiate MIT from experiences students have in K-12 education.

We note that the REST subjects, formerly "Science Area Electives," were introduced to enable "flexibility, choice, and early branching" within the GIRs and to help students explore career paths, and that lab subjects "would not be designed to teach specific subject matter or to provide broad coverage of a particular field; rather, they would be intended to give the students some real idea as to what laboratories are and what is meant by solving experimental problems in science and engineering" (Zacharias et al., 1964, p. 36, 37). These subjects have now been incorporated into major requirements and as a result, MIT's GIRs no longer have a mechanism that enables "flexibility, choice and early branching". We describe below existing and proposed offerings and strongly recommend the continued development of one-semester cross-cutting courses that integrate key disciplines and introduce some flexibility, starting with the SMC GIRs, but hopefully incorporating HASS GIRs in the future, as well.

Subjects should be developed by faculty in departments in consultation with downstream departments that require the class, possibly through the SMC subcommittee overseeing the requirements (see Governance). We propose that such courses would: 1) **Not be survey courses** and achieve the stated goals of the GIRs (above); 2) Introduce students to **discovery, innovative designs, and complex real-world challenges**; and 3) serve as foundational building blocks that cover certain topics reliably and at an intensity (6U or 12U) that can be prescribed by majors.

Process, Timing, Oversight

We propose that subjects in this category will all offer a 6-unit 'exposure' subject (preferably taught over the full semester) and/or an integrated 12-unit hybrid subject in which two disciplines in the category would merge their content such that the subject would count for 6-units in each discipline. For example, we recommend beginning with three integrated offerings, one of which already exists:

1. Computation + PSM
2. Computation + PSM + another related field, which would be 6.100A along with 6.C01 + x.C01 where 12 of 18 units counts as GIR
3. An integrated Chemistry + Biology subject, to be developed

Given that our recommendations would enable other departments to contribute to the GIRs, we propose that departments currently teaching the GIRs in question be asked to "peer review" any proposed new subject by the SMC committee during the evaluation process. This will ensure that any new subjects meet the rigor and learning objectives required of a MIT GIR.

We propose that students be allowed to take one of these integrated classes or two 6-unit exposure classes as part of their SMC GIRs, effectively allowing students to complete Chemistry, Computation, PSM, and Biology components of the SMC requirements using 36 units (i.e., 3 classes) with a combination of classes of their choice.

The final determination of course content and emphasis would be made by faculty and rest with the participating departments. Pilots should be designed starting in Fall 2027 that will serve to help departments decide how they want to set prerequisites for downstream courses and to improve the integrated and ‘exposure’ subjects before expansion to a wider cohort. Time will be needed to develop courses, so we suggest a launch as GIR options for a larger cohort in Fall 2028. The 12-unit courses for each subject would continue to be offered so that majors can rely on foundational building blocks in these courses, and/or students who want more advanced content or who have heard excellent feedback about a particular course can take them.

Impact on existing courses

We expect that this new model would decrease enrollment in 3.091, 5.11x, and 7.01x relative to current numbers, with students spreading their choice among the varying intensity options, depending on interest and future plans.

Majors that rely on Flexible Foundations courses as prerequisites can require that up to two of the four subjects be completed as non-integrated 12-unit versions. As prerequisites for departmental programs, all 6-unit versions of the Chemistry, Biology, and Computation GIRs (either standalone or integrated with another subject) would be treated as equivalent, and all 12-unit versions would be treated as equivalent. In other words, they would meet the same set of learning objectives. Majors can choose to specify a particular PSM subject or a limited selection of PSM subjects, but doing so would use up their 12 units of overlap with the GIRs. Here we emphasize the important distinction between having a department specify a particular subject (e.g., 18.05), which would entail using overlap units, and requiring a 12-unit version of one of the Flexible Foundations (e.g., 12-units of any PSM subject), which would not. In our recommendations, departments may *specify* up to 12 units of a subject for overlap, *and require* that two Flexible Foundations be taken as non-integrated 12-unit versions.

While some students may choose to take a 6-unit GIR and then later decide to pursue a major that requires 12 units of that GIR, initial estimates suggest that this practice will not be common. Most students arrive at MIT having already decided on either a specific major or a cluster of related majors that will likely require the same foundational GIRs. Undecided students, meanwhile, can be advised to select 12-unit versions of GIRs in areas they think they might like to pursue further.

TFUAP worked with Institutional Research to derive an initial estimate as to the number of students who might be in a “catch-up” situation, where they take a 6-unit flexible foundation but then enroll in a major that requires 12 units of that foundation. We obtained data on intended (at time of application) and chosen (at end of first year) major for the last 7 incoming classes, and then counted up students who intended a major that does not currently require Chemistry or Biology as a prerequisite for major requirements (and thus would be unlikely to specify 12-units of those flexible foundation) but then declared a major that currently requires 12-units of Chemistry or Biology. We found on average ~40 students per year per subject who would be in a catch-up situation for Chemistry and Biology. This is likely an overestimate of the actual number, because 1) students will organize their GIR choices to minimize the likelihood of being in a catch-up situation, and 2) students are more certain of their major at the time of matriculation than at the time of application, and even more so after one term on campus.

Given the small number of students who might ultimately take such a class, it will likely not be a good use of resources to offer a dedicated "catch-up" 6-unit class to bridge the gap between the 6 and 12-unit versions of a particular GIR. Strategies for students to catch up may include taking an ASE, taking the full 12-unit subject (noting that some material will be a review of the 6-unit subject they already took), or taking a 6 or 9-unit subject that meets with a 12-unit version but requires fewer assignments or exams. To facilitate as smooth a catch-up process as possible, TFUAP recommends that 12-unit versions and 6-unit versions be treated as distinct, such that a student may earn credit for both subjects or may sit for an ASE of the 12-unit version even if they have already taken the 6-unit version.

Feasibility of 6-unit and integrated courses

TFUAP has heard concerns about the feasibility of offering 6-unit exposure subjects in lieu of the current 12-unit options. In light of these concerns, it should be noted that many peer institutions on the quarter system (including Stanford, Caltech, Dartmouth, the University of Chicago, and Northwestern) teach robust and challenging courses over shorter terms with reduced content. In addition, the content included in a 12-unit course–although interesting and important–is not necessarily a fundamental, inviolable body of knowledge, exempt from critical consideration and curation.

We recommend that new 6-unit SMC GIR subjects be designed as full-semester subjects, not half-semester subjects. This is based on experience and feedback from students and instructors of the half-semester and full-semester versions of 6.100A Introduction to Computer Science and Programming in Python. Because of the half-semester calendar, the original half-semester 6.100A had to teach all the material in about six weeks, and students who fell behind (e.g. because of an illness) had no time to catch up. By contrast, the slower pace of the full-semester version (originally called 6.100L) gave students more time to learn and more safety cushion for adverse events. EECS has stopped offering the half-semester version and now only teaches 6.100A as a full-semester 6-unit course, and TFUAP recommends following this model for new 6-unit SMC GIRs.

In discussions with individuals and departments across MIT, members of TFUAP have heard exciting and rich ideas for integrated, interdisciplinary subjects, designed to motivate and inspire students, and to *strengthen* their understanding of core concepts across disciplines. Note the information on interdisciplinary teaching and the proposed support structures (Section 4 - Pedagogy & Appendix E).

Chemistry

TFUAP believes that Chemistry remains a fundamental discipline, both providing unique ways of thinking and providing essential literacy for understanding the molecular world. We believe that continued attention should be paid to ensuring that 3.091 and 5.111 are taught effectively so that all MIT students can build on a foundation in chemistry early in their time at MIT, and that integrated flavors or a 6-unit exposure subject will serve as a foundation for students not relying on the subject for further academic work at MIT. In addition to the solid state, there are biological applications of chemistry that could be highlighted through an integrated Chemistry and Biology course. Chemists are also taking advantage of computation to simulate and predict molecular reactions, which could be highlighted in a Chemistry and Computation course. Such interdisciplinary offerings would possibly be suitable for multiple downstream majors, emphasize the convergence between fields, and enable students to see how making unexpected connections between disciplines drives innovation in human knowledge.

Biology

TFUAP believes that Biology also remains a fundamental discipline, both providing unique ways of thinking (e.g., genetics, evolution) and providing essential literacy for understanding the living world, including ourselves. We believe that continued attention should be paid to ensuring that 7.01x’s are taught effectively so that all MIT students can build on a foundation in biology early in their time at MIT, and that integrated flavors or a 6-unit exposure subject will serve as a foundation for students not relying on the subject for further academic work at MIT. Furthermore, chemistry elucidates biology by enabling a deeper understanding of biomolecular structure and function, which could be highlighted through an integrated Chemistry and Biology class. Biology is also taking advantage of the latest computation and machine learning technologies, which could be highlighted through an integrated Biology and Computation class.

Computation

Rationale

In 2017, the Working Group on Computational Thinking concluded that: "Computational thinking should play an explicit role in the formal education of all undergraduate students at MIT. Computational thinking provides a distinct type of rigorous thought of intellectual value; it requires and develops important modes of communication; it acknowledges the need to understand the transformational impact of computation in other disciplines; and it creates opportunities and access for our students and graduates."

These findings from 2017 have only been reinforced in the years since. Computation has continued to transform the disciplines that MIT undergraduates study and the full spectrum of professions that they enter as graduates. Computational ways of thinking, encompassing the use of programming, algorithms, machine learning, and generative AI, are fast becoming essential for the current century, as calculus and differential equations were the foundation of engineering in the last century. In an Addendum to the Report of the Working Group on Computational Thinking shared with TFUAP, it was noted that among the 4,912 unique graduates in the classes of 2019 to 2023, 4,130 (84%) earned at least one S.B. with an explicit computational requirement (1,063 earned two S.B.'s), and many of the remaining 16% chose to take a computation class, leaving just 9% without formal exposure to computational thinking.

One potential criticism addressed in the 2017 Working Group's report is that a computing GIR is not needed, since >90% of MIT students already take such a class. However, this means that computing is already serving the "Foundational Building Blocks" function of the GIRs. Not including it in the GIR while expecting all students to take it creates a "hidden requirement" which adds to an already demanding education and reduces opportunity for deep work in the major or exploration.

That group noted that MIT's GIRs also function as "a statement to our community and to the world of what MIT believes to be of the utmost importance in its undergraduate education." TFUAP echoes that argument, noting that the absence of computational ways of thinking from our GIRs implies that MIT doesn't think computing is necessary in the 21st century, which is the exact opposite of the message we need to send. Our requirements should be communicating to prospective students and peer higher educational institutions that a basic understanding of computing is an essential part of what it means to be a technically literate college graduate in today's world. Similarly, our requirements should be telling employers and graduate schools that they can count on every MIT student to have facility in computational ways of thinking across a range of disciplines.

We also note that incoming students have had years of math and science during their K-12 education. In many schools, computing is an elective if it's offered at all, whereas students already have some requirement to take math, physics, chemistry, and biology in most US K-12 curricula, even if it's not at MIT's level. Students know they are behind, and they are using their scarce unrestricted electives to catch up. Furthermore, there is a recognition that computation is revolutionizing multiple fields. Acknowledging this convergence with interdisciplinary offerings would prepare our students to be the ones who make unexpected connections between fields and drive innovation in human knowledge.

Computing also needs to be in the GIRs to establish it as a course that students take early, in their first year or even first semester, as a foundational building block that covers certain topics reliably and at an intensity that can be prescribed by majors. Like Math, Physics, Chemistry, and Biology, we propose students take "some form" of computing by the end of their fifth semester so that instructors and departments are able to build on that foundation.

One may also wonder whether computing is becoming irrelevant with the advent of generative AI. However, we believe that this conflates computational thinking with the generation of program code. Saying "AI will take over programming" seems as simplistic as saying "digital calculators took over math." Digital calculators certainly do most of our arithmetic these days, but we still teach students how to do arithmetic because it helps them develop logical reasoning, the ability to recognize patterns and errors, and the foundation to learn higher-level math. Software like Mathematica and Wolfram Alpha has been used to solve algebra and calculus problems for decades, but we still teach students how to do that math for themselves. AI can solve an increasing number of science problems and generate text in a variety of styles – but we still believe that students should have science literacy and scientific 'ways of thinking' and learn how to structure an argument and communicate. AI will likely take over the writing of *straightforward* code, but students will, we believe, more than ever, need computational thinking to engage with it deeply, and hopefully steer its direction: understand how to translate a problem so it can be solved computationally, and how to recognize and debug incorrect algorithms.

Requirement

As a foundational building block for these skills, TFUAP recommends a new Computation requirement for all MIT undergraduates. We propose that subjects in this category will be: 1) a 6-unit, preferably full-semester, 'exposure' course; 2) a full-semester 12-unit course; or 3) an integrated course with one of the other disciplines in the category, which would allow students to see how computing is transforming certain disciplines. The courses that satisfy this requirement should include (1) instruction in a broadly-applicable, general-purpose programming language, so that many departments can use the subjects as foundational building blocks in their majors; (2) introduction to important kinds of algorithms and data structures, along with the analysis of their time and space behavior, to start forming the skill of selecting and adapting them to a problem; and (3) applications of computational modeling to problems in specific disciplines, which might include machine learning, simulation, or optimization.

Existing courses that satisfy these requirements include:

- 6.1000 Introduction to Programming and Computer Science (12 units)
- 6.100A Introduction to Computer Science Programming in Python (6 units, full semester)
- In addition, combining 6.100A and any of the other two below would be another 12 units option:
    - 6.100B Introduction to Computational Thinking and Data Science (6 units, full semester), or:
    - 16.C20/18.C20/9.C20/CSE.C20 Introduction to Computational Science and Engineering (6 units, full semester)

As generative AI is rapidly changing the practice of programming, enabling people with little or no programming experience to write code, the Computation requirement should continue to emphasize a deep understanding of algorithmic behavior, the ability to communicate that behavior through precise language, and at least reading fluency of a general-purpose programming language.

Probability, Statistics, and Machine Learning

Rationale

We live in an increasingly data-rich world, which has been transformed recently by developments in machine learning and artificial intelligence. MIT graduates need to understand the underlying basis for interpreting noisy data, both for preparation for their majors and as future citizens. Many of them are already users of AI, but MIT graduates, of all people, need to be those who understand what is "under the hood", no matter what career they will pursue. Highlighting the importance of this preparation, many majors already have some sort of requirement or option governing probability, statistics, and/or machine learning[7]. Because probability, statistics, and machine learning are already serving the "foundational building blocks" principle for many students and constitute an essential area of literacy and set of tools in today's world, we propose to formalize this requirement broadly across MIT in order to ensure that *all* our graduates have this knowledge.

Unlike the rest of the proposed SMC GIRs, instruction in probability, statistics, and machine learning occurs to varying degrees across all five Schools and the College, and techniques for doing so often rely on discipline-specific needs. Leveraging that existing wealth of expertise while ensuring all MIT graduates achieve a baseline level of literacy represents a novel opportunity for departments not historically involved in teaching the GIRs to play a role. While TFUAP recommends that the content be foundational and applicable to follow-on classes in multiple departments, TFUAP welcomes and encourages multi-department efforts that draw on discipline-specific examples to teach broadly relevant concepts. We expect these subjects to be dynamic, interdisciplinary, and exciting to develop and teach.

Requirement

We propose that this requirement be met by having students complete one subject from a list of subjects curated by a new subcommittee of CUP, the Subcommittee on the Probability, Statistics, and Machine Learning Requirement (SPSMR). Subjects meeting the requirement should have the following properties:

- 12-unit subjects must cover at least two of the three elements of probability, statistics, and machine learning; 6-unit subjects must cover at least one of the three elements. We are aware that it may be overly challenging to meaningfully provide a solid foundation of all three topics in 12 units or two topics in 6 units, hence our choice.
- Subjects need to have substantial mathematical, broadly applicable content. As a GIR, these subjects are intended to be foundational rather than narrowly applied to a single discipline. That said, learning probability, statistics, and machine learning without

[7] Depending on the criteria one uses, between 15-22 Courses require instruction in probability, statistics, and/or machine learning. Those majors collectively award between ~400 and ~850 degrees/year, making this requirement one of the most broadly distributed at MIT.

reference to real-world examples does not make a whole lot of sense, hence the balance. We believe that at least half the course content should be foundational rather than applied.

- Subjects should build on the new computing GIR (it should be a prerequisite) and meaningfully incorporate computation. This will be natural in a subject that covers machine learning, but even a more classical probability and statistics subject should go beyond hand calculation.
- Subjects should count toward degree programs in at least two different departments, and ideally should be jointly taught. This provides multiple beneficial features – it provides some counter-pressure against the list of classes getting too long and specialized, and it promotes cross-departmental teaching and collaboration.
- In some cases, it may be appropriate for students to take two subjects in their major that collectively satisfy the PSM GIR (e.g., one 12-unit subject on probability and another 12-unit subject on statistics). TFUAP recommends that the SPSMR create guidelines to handle such requests with the goal of achieving expected learning outcomes while also not penalizing students who study these topics in greater depth than what is required. In such a case, the major would be specifying 12 units of a GIR subject, and the major would have to count the remaining 12 units towards their 14.5 subject limit.

Existing subjects that may meet the requirement

While few subjects meet the requirement at the outset, many subjects could meet the requirement with some adjustment. Although we list some putative classes below, the SPSMR will have to evaluate each one against the specification to ultimately decide whether they qualify for the requirement or how they might need to evolve to do so. The list below is not intended to be complete, as it will be up to the SPSMR to consider the entire list of possible subjects.

- *6.3800 Introduction to Inference* covers aspects of probability, statistics, and machine learning, emphasizing computation. It counts toward multiple degree programs.
- *14.30 Introduction to Statistical Methods in Economics* teaches students probability and statistics with applications in economics and the social sciences.
- *18.05 Introduction to Probability and Statistics* teaches both probability and statistics, counts toward multiple degree programs, and uses computational tools.

Process, Timing, and Oversight

We propose that the requirement be overseen by the SPSMR, comprising approximately 10 faculty across the five Schools and the College, along with students and appropriate *ex officio* members.

The SPSMR will develop detailed criteria for PSM subjects and approve an initial list of subjects in AY 2027-28, which may involve working with instructors and departments to adjust existing subjects to meet specifications. After the list is complete, the SPSMR will continue to oversee the requirement, including evaluating new subject proposals and periodically (approximately every five years) reviewing existing subjects.

Impact on existing courses

Existing courses can specify that a subject on this list meets their major requirements; indeed, it is a requirement for subjects to be on the list that they meet the needs of at least two departmental programs. Thus, in some cases, this will provide extra space in a student's UG experience.

More importantly, we hope that majors will take advantage of the widespread knowledge of probability, statistics, and machine learning, and build on that in other classes in their departmental programs.

REST and Institute Lab

The Restricted Electives in Science and Technology (REST) and Institute Laboratory (Lab) requirements were originally conceived as part of the overall collection of Science, Math, and Engineering GIRs. REST subjects, formerly "Science Area Electives," were expected to enable "flexibility, choice, and early branching" within the GIRs and to help students explore career paths (Zacharias et al., 1964, p. 37). Lab subjects "would not be designed to teach specific subject matter or to provide broad coverage of a particular field; rather, they would be intended to give the students some real idea as to what laboratories are and what is meant by solving experimental problems in science and engineering" (p. 36). While the Committee on Curriculum Content Planning, now known as the "Zacharias Committee," noted that both Science Area Electives and Lab classes could support sophomore-level study in the majors, they cautioned that departments should be able to prescribe at most 2 of the then-4 subjects. The 3-subject Science Area Elective requirement later became the 2-subject REST requirement when biology was added to the science core, and the current rule is that at most 1 of the 2 REST subjects may be completed in a student's major. However, departments are allowed to specify up to three GIR subjects, and many choose to require one REST and one Lab subject within their department and one REST subject in a foundational area such as math or computing that serves the department's needs. As a result, students often give little thought to REST and Lab requirements and treat them as simply required classes in their majors.

Given this evolution of the REST and Lab requirements and our proposed change to incorporate a "flexible foundations" category for GIRs, TFUAP recommends eliminating both requirements. We still endorse the goals of both requirements, but feel that other proposed requirements will better serve these goals. Our revised SMC GIRs incorporate more unique areas of study than the prior science core, adding some engineering and computing content and therefore enabling broader exploration within the core. Likewise, the updated math requirements and new computation and probability, statistics, and machine learning requirements provide a broadly useful foundation for further study in most engineering and science fields.

TFUAP heard from community members about the importance of hands-on learning. TFUAP agrees that hands-on activities are integral to MIT's undergraduate experience. The Lab requirement, though, does not enforce hands-on learning (see FAQ); many majors have Lab subjects that are not "hands-on". Conversely, "hands-on" learning takes place extra-curricularly, e.g., through UROP, clubs, D-LAB projects, makerspaces, etc.

TFUAP discussed at length different mechanisms for promoting hands-on learning. Students currently engage in a wide variety of hands-on learning, including some UROPs (not all UROPs are hands-on, but many are), existing Institute and departmental lab subjects (2.009, 6.2050, 8.13, etc.), Edgerton Center clubs (Motorsports, Rocket Team, etc.), and personal projects in Makerspaces, just to name a few. Ultimately, we decided that *mandating* hands-on work might kill the joy that many students feel when doing such activities, and replace one of our most cherished traditions at MIT with just one more box to check. Instead, we come down on the side of *celebrating* hands-on work via a new icon as described in our Experiential Learning section.

We expect that removing the Lab requirement will not affect lab classes that exist as part of majors, recognizing the value of hands-on learning and working on projects that approximate the work of a professional in that field. Most hands-on laboratory subjects are *not* Institute Lab subjects, and the disciplines that pride themselves on hands-on work are not going to remove those subjects from their majors.

Impact on Major Requirements

REST and Lab have, for many years, been used by majors to effectively increase their maximum size from 12.5 subjects as specified in the Faculty Rules and Regulations to 15.5 subjects, relying on a rule that allows departments to "specify" up to 36 units of overlap with GIR subjects.

Given the new proposed requirements and the need for many majors to continue to require the classes previously included in these categories, TFUAP proposes the following:

- The maximum major size will be raised from 12.5 subjects to 14.5 subjects.
- Departments will be allowed to specify up to 12 units of GIR subjects. We expect that this may include a Probability, Statistics, and Machine Learning (PSM) subject, a Teamwork-Intensive subject (described below), or a HASS subject.

TFUAP feels that this new approach to major sizes will grant the majors more flexibility in their requirements without overly constraining student choice within the GIRs and without negatively impacting the number of unrestricted electives available to students.

It is critical to note that removing the REST and Laboratory requirements does not immediately free up units (see FAQ), as those spots are already taken up by departmental requirements.

At the end of this report, we provide a detailed assessment of the impact of our consolidated recommendations on existing courses. We found that majors should not be constrained if they allow modest changes to incorporate some of the new requirements (like allowing the new computing class to substitute for their existing computing requirement).

2B: HASS

Rationale

The humanities, arts, and social sciences are more important than ever. We live in a world where social, political, technological, economic, and environmental changes are accelerating, sometimes exponentially. Our lives and communities are rapidly becoming more complex and more diverse, but often with more silos. The world and the social systems that we collectively want for a digital age may be quite different from the systems that have been built for an industrial age. Our most pressing challenges are multisystemic. Individuals whose main expertise is technical end up making choices that are consequential for the lives of many people, and many of our students may eventually find themselves in this position.

Our students will need a broad understanding of human creativity, socio-cultural, economic, and political phenomena, and of how to engage constructively with others about moral and social questions in order to meet these challenges.

Given these needs, TFUAP strongly affirms the fundamental importance of the humanities, arts, and social sciences to general education. And as new questions for these disciplines continuously emerge with developments in artificial intelligence and automation, MIT must equip students with the tools and frameworks for "human intelligence" supported by the HASS requirement—critical reasoning, creativity, communication, and moral, intellectual, and aesthetic judgment.

As described in the MIT Bulletin, MIT's requirement in the humanities, arts, and social sciences aims to equip students with a "broad understanding of human society, its traditions, and its institutions." The requirement seeks to enable students to deepen their knowledge in a variety of cultural and disciplinary areas and develop sensibilities and skills vital to an effective and satisfying life as an individual, professional, and member of society. SHASS departments and units consistently rank as some of the very best in the world. The foundational report provided for the task force's internal use by the Subcommittee on the HASS Requirement (SHR) notes that HASS instructors are dedicated, creative, and passionate about their research and teaching, HASS subject offerings and concentration fields are robust, and students have an abundant amount of choice as they navigate the requirement and pursue their HASS interests.

The requirement is structured to provide both breadth across HASS via the three-subject distribution requirement and depth within a HASS discipline via the three-or-four subject concentration.

The SHR report articulates the breadth requirement:

> "Students gain general knowledge of the humanities, arts, and social sciences through completion of the Distribution Component. To ensure breadth, students must complete three subjects, one from each of the following categories: Humanities (HASS-H), Arts (HASS-A), and Social Sciences (HASS-S).

The SHR report goes on to describe the concentration:

> "Students gain a deeper understanding of a humanities, arts, and social sciences subfield through completion of the Concentration Component. To ensure depth, students designate a field of concentration and complete three or four subjects (some fields require three, some four) that together provide an increased knowledge and understanding of the issues and methodologies in a particular area of study."

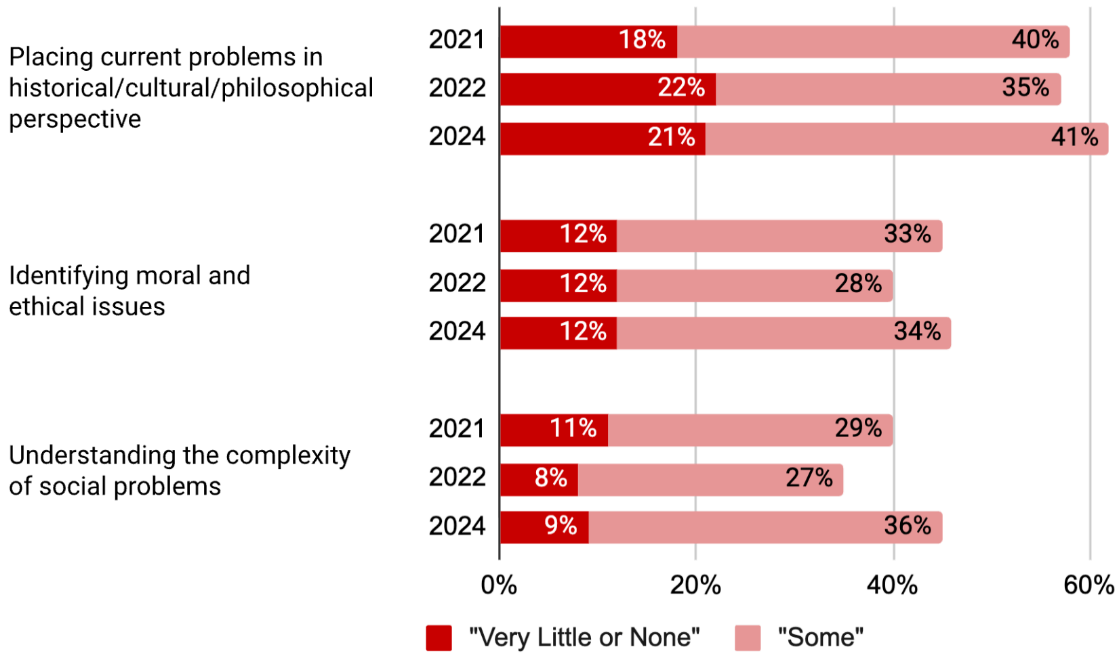
Generally, the task force believes that the HASS requirement works well. However, students can and do satisfy the current HASS GIR requirements through combinations of classes that enable them to graduate without all of the essential capabilities, knowledge, and habits of mind that are provided by the offerings in the humanities, arts, and social sciences, and that are the stated goal of the requirement. Graduating MIT seniors demonstrate this variability when reflecting on their MIT learning through the Senior Survey, with many students noting that MIT did not contribute to their learning on certain key learning outcomes (Figure 4). In particular, while many graduating students did feel that their experience at MIT had contributed to their ability to understand moral and social issues and to put them into historical, cultural, and philosophical context, a significant fraction– between 8 and 22 percent – felt that their MIT experience had contributed very little or none to their capacities in these areas. By comparison, only 1% of respondents each year said their MIT experience contributed very little or none to their knowledge, skills, and personal development in the area of "understanding and using quantitative reasoning and methods."

During our listening tour, TFUAP heard repeatedly about the importance of education in moral and social issues from groups across all MIT Schools and across faculty, staff, students, and alumni. Several community members also took the time to write white papers explicitly advocating for a GIR on some aspect of moral, social, or ethical perspectives. This is consistent with the findings of the SHR report, which states that "there also appears to be a desire across the Institute to incorporate ethics and other contemporary topics into the curriculum." This is also consistent with the report from the Task Force 2021 and Beyond, which calls on MIT to "fulfill our public responsibilities and imbue our values and ideals more fully in our community and culture and in the education of our students" (p. 7).

In its review of MIT's undergraduate academic program in 1949, the Lewis Report stated that "the first objective of education is to develop in students a sense of values in order that they may have those qualities — wisdom, judgment, tolerance, independence of thought, and critical sense — that mark an educated man" (p. 89) and noted the central role of subjects that are "humanistic in their spirit, outlook, and content" (p. 99) in developing this sense of values and soundness of judgment that all MIT students should cultivate ([Lewis et al., 1949](#)). It is clear that there are many subject offerings in the humanities, arts, and social sciences that support students in developing these capacities. TFUAP's recommendations below aim to ensure that students take a combination of classes that provide an **explicit opportunity** to focus on developing a sense of their values and principles as well as their civic and moral commitments, gain knowledge about ethics and civic engagement in different historical and cultural contexts, and apply these to real-world social and ethical questions with an understanding of their social, economic, and political contexts.

Figure 4

To what extent has your experience at MIT contributed to your knowledge, skills, and personal development in the following areas?



Data from 2021, 2022, and 2024 Senior Surveys conducted by MIT Institutional Research. The remaining response options were "quite a bit" and "very much."

Requirement

We propose that students continue to be required to take eight HASS subjects and that the existing distribution and concentration requirements remain the same.

As of now, students are required to take one subject from each of the following three categories ([as described in the MIT Bulletin](#)):

- Humanities. Humanities subjects describe and interpret human achievements, problems, and historical changes at individual as well as societal levels. Although humanist inquiry employs a variety of methods, such disciplines as history, literature, and philosophy typically produce their accounts of cultural accomplishments through close analysis of texts and ideas: contemporary and historical, personal and communal, imaginative and reflective.

- Arts. Arts subjects emphasize the skilled craft, practices, and standards of excellence involved in creating representations through images, words, sounds, and movement (e.g., sculptures, stories, plays, music, dance, films, or video games). Although arts subjects also engage in critical interpretation and historical analysis, they focus more centrally on expressive and aesthetic techniques and tools, such as the uses of rhythm, texture, and line.

- Social sciences. Social science subjects engage in theory-driven as well as empirical exploration and analysis of human transactions. They address the mental and behavioral activities of individuals, groups, organizations, institutions, and nations. Social science disciplines such as anthropology, economics, linguistics, political science, and psychology seek generalizable interpretations and explanations of human interaction.

The Concentration is three or four subjects. At least one must be an upper-level subject.

In addition to the existing distribution and concentration requirements, TFUAP recommends that students be required to take at least one subject designated as a Moral and Civic Perspectives subject in a way that is analogous to the CI-H designation. Like CI-H subjects, Moral and Civic Perspectives subjects may also simultaneously satisfy a distribution, concentration, or elective requirement.

We propose that Moral and Civic Perspectives subjects systematically explore how individuals, communities, and societies grapple with questions of value, responsibility, significance, community, justice, and the greater good. The idea is certainly not to promote a specific worldview or ethics, but rather to equip students with the tools and knowledge to make their own principled choices throughout their personal and professional lives.

We recommend that Moral and Civic Perspectives subjects have one or more of the following as one of their **primary** learning objectives. A preliminary review of HASS subjects suggests that several departments have classes that would satisfy those requirements:

- Understand and evaluate diverse theories about how to determine what is right and wrong, and learn how to apply them to difficult questions in rigorous, disciplined ways
- Analyze how ideas about values, ethics, and civic responsibility emerge from and transform the economic, social, and cultural contexts in which they are embedded
- Explore real-world ethical dilemmas and develop practices of critical reflection about the alignment of one's values and commitments with one's decisions and actions in one's personal, professional, and public lives

While TFUAP currently recommends that students be able to satisfy the MCP requirement at any time during their MIT education, we note that it may be especially valuable if taken in a student's first year. Early exposure to MCP topics would give students a moral and civic foundation that can serve them through later experiences like internships, classes on professional ethics, and as they participate in campus civic life as members of the MIT community. We recommend that the MCP subcommittee described below work with SHR and CUP to study the possibility of a pacing requirement for MCP, noting any impacts on other aspects of HASS such as CI-H and concentrations.

We also note that developing moral and civic perspectives requires sustained engagement with these questions across multiple contexts within the student experience, so we encourage MIT to explore ways to reinforce these concepts beyond the required MCP subject.

Why not require Moral and Civic Perspectives in the majors?

Some community members have suggested that the MCP requirement should be taught within majors, giving students an opportunity to wrestle with the moral and civic questions in a disciplinary context. While TFUAP notes that moral and civic education would be a valuable addition to most, if not all, majors, TFUAP also notes that the MCP requirement is meant to serve as a fundamental part of students' *general* education, not limited to their *professional* education.

The learning goals of the MCP requirement, listed above, comprise areas with robust scholarship across the humanities, arts, and social sciences. Addressing these topics in a rigorous, foundational way demands scholarly expertise, grounded in the social sciences and humanities.

At the same time, requiring that every student at least have a foundation in moral and civic perspectives as understood in the humanities and social sciences should not preclude incorporating instruction of moral and civic topics within science and engineering majors. Ensuring that students understand the moral and civic dimensions of their professions is a core responsibility of all faculty, not just those in the humanities and social sciences. TFUAP encourages non-HASS departments to audit the moral and civic educational experiences within their majors and review relevant accreditation standards and disciplinary guidance as well as explore partnerships, whether through jointly taught classes with HASS faculty that can satisfy the MCP requirement or by developing disciplinary and interdisciplinary classes that build on MCP content. Professional learning experiences for faculty about the moral and civic foundations of their professions and disciplines, and about teaching moral and civic reasoning in their fields, would also be beneficial. TFUAP encourages the use of curriculum development funds for this purpose, noting that interdisciplinary teaching and/or curriculum development can pose unique costs.

Process, Timing, and Oversight

We recommend that HASS requirements continue to be overseen by the SHR. Ideally, each of the categories would be represented and reviewed by at least two faculty members from different departments who have experience teaching in that category.

An ad hoc MCP subcommittee of CUP will be charged with developing a process for certifying and curating the limited list of Moral and Civic Perspectives subjects, which may involve working with instructors and departments to adjust existing subjects and develop new subjects to meet specifications. After the list is complete, the subcommittee will continue to oversee the requirement, including evaluating new subject proposals and reviewing existing subjects every three years.

Our proposed Moral and Civic Perspectives requirement should undergo annual reviews by the relevant subcommittee and an interim review by CUP after approximately 5 years, with a comprehensive evaluation for effectiveness approximately 10 years after implementation. This would allow assessment of ~6 graduating classes. Of course, although we ultimately care about how the requirement affects students well after graduation, that would require waiting 15-20 years, which is too long. As the MCP subcommittee develops the certification process for Moral and Civic Perspectives subjects, we encourage them to develop strategies to assess the effectiveness of the requirement. The evaluation of the requirement should be undertaken by an independent body, such as CUP or an ad-hoc committee. The results should be shared with the community and used to continue, revise, or abandon the requirement.

Why Eight Subjects?

While conversations with the MIT community have highlighted a near-universal support for requiring HASS subjects for all MIT students, some community members have questioned whether it is necessary to require eight subjects, suggesting that a six or seven-subject requirement might achieve the same aims while freeing space for other objectives. TFUAP discussed the possibility of reducing the size of the HASS requirement but ultimately concluded that an eight-subject requirement was appropriate.

The eight subjects in the HASS requirement are not a monolith. The first half of the requirement provides a broad foundation, exposing students to multiple disciplines with unique objectives and scholarly traditions. The second half adds depth, requiring students to develop greater fluency in a particular discipline or cross-disciplinary field through repeated exposure over multiple subjects. While these two parts of the requirement could be completed in 6 or 7 subjects, requiring 8 gives students the bandwidth to explore through one or two electives before deciding on a concentration or to pursue interdisciplinary subjects that do not satisfy either the distribution or concentration requirements. Building in flexible subjects by design also reduces the pressure to maximize each subject, instead selecting subjects based on intellectual curiosity.

Some community members have also highlighted the value of requiring eight HASS subjects over what is typically an eight-semester undergraduate program. Given the distinct ways of working and learning within HASS fields as compared to STEM fields, students and faculty alike have noted that taking one HASS subject alongside three to four STEM subjects provides a useful intellectual balance, complementing problem sets and projects with the reading, writing, and discussion common to HASS subjects, and helping to integrate their scientific and technical learning with humanistic education. That said, this experience is not universal; many students major in non-STEM fields or take multiple HASS subjects in some semesters and no HASS subjects in others.

Adding Flexibility in HASS

While TFUAP ultimately decided that the HASS requirement should remain 8 subjects, we recommend the following steps be taken to give students more flexibility in how they complete those subjects:

1. Departments offering HASS subjects should encourage the creation of more HASS subjects during IAP. HASS classes that benefit from the intensive timeline, opportunities to travel, or the curious and creative spirit of IAP are especially encouraged to consider IAP offerings.
2. Departments should consider granting AP, IB, and/or ASE credit for introductory subjects in their fields when an appropriate examination is available or, in the case of ASEs, could be created. Depending on how closely the test maps to the material and skills covered in an existing MIT course, a satisfactory test score could offer credit for a HASS elective, a distribution requirement (if a comparable class counts for that requirement), or an introductory subject in a concentration. This determination would be left to the department(s) with the relevant expertise. TFUAP notes that granting this sort of credit could encourage more students applying to MIT to study HASS subjects at a high level in high school and may encourage more students who excel in HASS subjects to apply to MIT. Students with credit for introductory HASS subjects may also opt to pursue more advanced HASS coursework upon arrival. TFUAP suggests that incoming credit for HASS subjects be limited to 1 or 2 subjects so that the vast majority are still completed while at MIT.

Other recommendations

In addition, TFUAP recommends that SHR, in consultation with HASS instructors, develop a strategy to inform students and advisors about the learning goals of the existing HASS-H, A, and SS categories and offer guidance about how to select intellectually fulfilling HASS distribution and elective subjects. While advising is outside of TFUAP's charge, we recognize that better advising about HASS subject selection could address many of the concerns we heard from the community about how students approach the HASS requirement.

2C: Communication-Intensive (CI)

Rationale

The importance of students learning multiple types of communication came up broadly in TFUAP's listening tour. In addition, many alumni survey responses expressed the value of the communication skills they developed from the MIT Communication requirement, noting it as a critical aspect of their current work.

One sentiment that arose in TFUAP discussions was the importance of visual communication, which is often left out in favor of written and oral communication. With technology making communication practices like graphic design, data visualization, diagramming, and even video more accessible to all, it is vital that our graduates are able to harness visual media to communicate. Similarly, the idea of an "audience" has been complicated by technology, and graduates should have experience considering the different approaches needed to reach their target audience through different platforms and media.

We also note that "communication" can often focus more on speaking/writing than listening and facilitating communication, and we feel it is important to name that communication should be reciprocal. Likewise, many people in the listening tour mentioned that communicating to multiple types of audiences (e.g., expert/non-expert), as well as with those whose views differ from our own, was important for our students to learn.

Requirement

The number of CI-H/HW and CI-M classes and pacing requirements will remain the same. TFUAP recommends that the Subcommittee on the Communication Requirement (SOCR) update the criteria for CI classes to explicitly require at least some subjects to teach visual communication and communication to non-expert audiences. TFUAP recommends that these skills specifically be taught in CI-M classes, but leaves the exact implementation to SOCR's discretion.

TFUAP also recommends that SOCR embark on a period of encouraging and licensing expansive experimentation and innovation in CI classes. Experiments need not adhere to the current CI requirement, but should provide objectives, rationale, and evaluation strategy. MIT should provide resources to support this experimentation and documentation of lessons. Based on this period of study and experimentation, TFUAP recommends that SOCR update the guidelines for the communication requirement within five years.

Process, Timing, and Oversight

To ensure that every student learns visual communication and communication with non-expert audiences and those with differing viewpoints, SOCR will need to implement a process for embedding these skills in existing and new CI classes and recertifying existing classes. This may include a phased implementation process whereby departments are expected to revise one of their CI-Ms to meet the new guidelines within a shorter timeframe (e.g., by the fall of 2027) and will have an additional 2-3 years to update the remaining CI classes. SOCR should determine the specific timeline in consultation with Writing, Rhetoric, and Professional Communication (WRAP). MIT may need to hire additional instructors with expertise in visual communication, which would delay the timeline.

SOCR would be expected to encourage, license, and monitor experimentation in new and existing CI classes to reduce reliance on word counts and explore new ways to teach and assess communication. Experiments should explore a range of communication styles, genres, mediums, and audiences. AI may be incorporated as a tool when appropriate, and experiments involving AI should be conducted in consultation with the newly charged Task Force on AI in Teaching and Learning. Interpersonal communication skills such as debate, listening, facilitating, and providing feedback should be encouraged in experiments. SOCR will report annually to the CUP on these experiments and share lessons with CI instructors. Pending interest from faculty governance, SOCR may also report directly to the full faculty on an annual or biannual basis.

Within five years, SOCR will propose a revised set of guidelines for the communication requirement, considering both the implications of AI and broader goals around the types of communication MIT students should master, and present them to the full faculty.

2D: Teamwork-Intensive (TI)

Rationale

TFUAP's Learning Goal 4 states that "every MIT graduate will be able to work collaboratively in teams, give and receive productive feedback, and take on leadership roles." TFUAP believes that interacting with peers through impromptu conversations, idea exchange, and face-to-face communication and collaboration teaches vital lifelong skills and is one of the unique benefits of a residential college education. In addition, teamwork, involving groups (3+) of peers toward a common goal over a sustained period, enhances students' abilities to engage with different perspectives (LG5) and practice critical listening and thinking (LG6). Much like communication, teamwork is a skill that should be explicitly taught and practiced.

Requirement

All MIT students will be required to take at least one "Teamwork-Intensive" (TI) subject during their time at MIT. TI subjects can be taken within or outside students' majors, but departments may choose to specify a TI subject as part of their major requirements.

To be designated as Teamwork-Intensive, a subject must include:

- Instruction on effective teamwork practices. Instructors may adopt a variety of pedagogical approaches to this, including teaching strategies for effective teamwork before students begin to work in teams or providing guidance and reflection opportunities during or after the teamwork experience, but effective teamwork should be an assessed learning goal in the subject.
- One or more team-based assignments, where a “team” consists of 3+ students, that collectively comprise a substantial portion of the subject grade.

Process, Timing, and Oversight

We recommend that a new Subcommittee on the Teamwork Requirement (STR) be charged with establishing and maintaining a set of qualifications for subjects to be designated as Teamwork-Intensive. STR will also collaborate with TLL and other experts on teamwork to create teaching materials, such as sample team contracts, workshops on teaching teamwork, and Canvas modules to facilitate the rapid adoption of evidence-based practices for teaching and engaging in teamwork.

STR will work with departments to certify existing subjects as Teamwork-Intensive and ensure that enough such subjects are available to students before the requirement is implemented.

Based on a preliminary review of majors, TFUAP found that many majors already include team-based project classes and therefore would be able to implement a TI class with little to no changes to their curriculum. Other majors might need to make teamwork a larger part of a particular class, create a new TI class, or decide that their students should select a TI class outside of their major (similar to how Lab and REST have been used in non-STEM majors).

Resources and support for departments and instructors in the development of subjects to help build students' ability to work effectively in teams already exist at MIT. For example, the new and ongoing work of the MIT Dialogue Collaborative (DC), formed by DSL & ORSEL, the Gordon Engineering Leadership Program (GEL), and the Center for Constructive Communication, among others. These programs provide both formal and informal opportunities for students to gain essential skills in active listening, empathy, and understanding, and can augment and support the development of teamwork skills in academic subjects.

2E: Physical Education and Wellness

Rationale

MIT has long had a Physical Education requirement for students to receive “the instruction and skills necessary to lead healthy, active lifestyles and to foster both personal growth and a sense of community through physical activity,"[8] and the requirement was expanded in the past decade to include instruction in wellness as well as physical education. The requirement has always been modest, requiring just 8 points, or four quarter-long classes, in total (there are two quarters in each semester, plus additional classes are offered during IAP).

While TFUAP had originally proposed increasing the requirement to 10 points, further discussion with the MIT community made it clear that factors such as limited space in many PE+W classes, challenges with the registration process, and the timing of PE+W classes made this recommendation concerning to students and DAPER staff alike. Given these hurdles and the fact that our goal is to reduce stress rather than add to it, TFUAP decided to recommend that the PE+W requirement remain at 8 points, but also to suggest that steps be taken to broaden the formats of PE+W opportunities and more seamlessly integrate PE+W into students' academic experiences.

TFUAP received a white paper from DAPER outlining a few strategies for achieving these aims. TFUAP found suggestions such as cohort-based PE+W classes (such as for first-year learning communities) and pairing academic subjects with complementary PE+W classes (such as a subject on Buddhism with the fitness and meditation class) particularly compelling. TFUAP also received many creative and compelling white papers from the community discussing ways to teach wellness concepts to students, and we encourage DAPER to explore these ideas and reach out to the white paper authors as appropriate.

Requirement

TFUAP recommends that the PE+W requirement remain 8 points, and that steps be taken to increase the number and variety of offerings and reduce friction in the registration process. TFUAP especially encourages an increase in PE+W classes with content, timing, and registration processes designed to complement existing academic classes and cohorts. However, attention should be paid to ensure that an increase in targeted classes does not limit PE+W access for students who are not in the participating cohorts or academic subjects.

2F: Experiential Learning

Hands-on education has been a defining feature of the MIT academic experience since its founding. MIT's motto, "mens et manus" or "mind and hand," highlights the importance of hands-on and applied learning as a complement to the work of the mind. TFUAP specified in our goals that an MIT education should include experiential learning and hands-on making/breaking (process goal 3), experiences that many community members described as quintessential parts of an MIT education. Rather than enforcing these experiences as requirements, which could create unnecessary rigidity around something that nearly all MIT students already seek out voluntarily,

[8] https://catalog.mit.edu/mit/undergraduate-education/general-institute-requirements/#physicaleducationtext

TFUAP proposes that MIT engage in a deliberate effort to elevate what already exists through labeling, tracking, and financial support. Note that, unlike the SMC requirements, these experiences are unlikely to be needed as foundations for subsequent coursework, and can be readily attained through extra-curricular activities (like clubs, personal projects, etc.).

Labeling Hands-on and Experiential Classes and Opportunities

Rationale

Many in the community have noted the value of hands-on and experiential classes and opportunities at MIT. These can take the form of lab classes like Physics Junior Lab, project-based classes like 2.009, co-curricular programs like UROP, or purely extracurricular pursuits like student maker projects. For some people, these experiences needed to involve physical making, breaking, or experimentation, allowing students to engage with the physical world first-hand in all its complexity and develop intuition that goes beyond theory. For others, the experiential or authentic nature of the learning, or the contact with real-world people and problems (sometimes in other countries) and the learning that occurs through subsequent reflection was more important. For them, the work need not be tactile or physical, but it should involve authentic, real-world challenges with unknown answers, and ideally, interaction with the world beyond MIT.

TFUAP believes that both hands-on and experiential/authentic learning have incredible value, but are not suited to every subject or even every major, so rather than requiring that all students engage in one or both types of learning, we propose that both types be highlighted in the subject listing. Labeling subjects has benefits for students, advisors, and departments. Students who enjoy these types of learning can easily find these classes and choose what to take to achieve their desired balance of mind and hand. Advisors can point students towards opportunities that will help them explore, get inspired, or understand the applications of their lecture-based coursework in new ways. Departments can compare the popularity of these classes to other types, consider how different learning experiences are distributed across a typical degree path, and promote electives to students seeking hands-on or experiential opportunities.

Description

TFUAP proposes that two new designations be adopted. We tentatively refer to these as "hands-on" and "experiential" and describe each below, but final terms should be determined through community input and review of relevant educational literature. Each would have a definition and set of evaluation criteria, which would be determined by a working group including representatives from the Committee on Curricula and the Office of Experiential Learning. While TFUAP defers to this group on the exact terms and definitions and how much of a subject must involve hands-on or experiential learning to qualify, we conceptualize the two categories as follows:

- "Hands-on" refers to subjects and opportunities that involve a substantial amount of student engagement with the physical world. This could include "making" (creating a physical artifact), "breaking" (disassembling, debugging, repairing, or adapting a physical device), or engaging in hands-on experimentation. This would not include creation, debugging, or experimentation that is purely computational or mathematical. TFUAP recommends that the working group consider questions like whether and how to include musical performance and other creation of physical phenomena that do not result in a material product in the definition. Alternative labels could include “tactile,” “embodied,” or “physical world.”

- “Experiential” refers to subjects and opportunities that engage students in authentic work in real-world contexts or with non-MIT partners and stakeholders. This may include project-based work with community partners or clients, or research experiences that lack a pre-defined outcome, but typically involves outcomes or deliverables with audiences beyond the instructor and stakes beyond receiving a grade. TFUAP recommends that the working group consider questions like whether a carefully constructed simulation of a real-world context should qualify as experiential. Alternative labels could include “authentic learning” or “action learning” (currently used in Sloan) or could focus on subtypes of experiential learning such as “community-engaged learning.”

We recognize that there will likely be a substantial overlap between these categories, but note that the two definitions differ in meaningful ways. For example, a hands-on subject might involve recreating classic experiments, developing a tactile familiarity with some of the processes of conducting research, and making visible a set of key scientific principles. This subject, however, would not be experiential as it lacks the challenges of authentic research that come from crafting and testing an unproven hypothesis. A subject that involves analyzing campus HVAC usage to make recommendations to facilities staff to reduce emissions, meanwhile, might be experiential as it involves authentic data and an audience beyond the instructor, but it would not be “hands-on” under this definition as it lacks a tactile component.

Process, Timing, and Implementation

TFUAP recommends that a working group, consisting of faculty, staff, and students including representatives from the Committee on Curricula and the Office of Experiential Learning convene during AY2027 to decide on appropriate terms and develop definitions and criteria. CoC and the Registrar’s Office should determine the best process and timeline for certifying existing subjects, noting that system updates may be necessary for full implementation and committees might be occupied by other TFUAP recommendations during upcoming academic years.

TFUAP also recommends that an icon be developed for each category and that these apply to co- and extra-curricular opportunities as well as classes. These icons could be displayed on program websites, in the MIT Subject Listing, in other systems such as ELx, and in marketing materials. The associated designations should also be used in the experiential learning tracking system described below. The working group should determine an efficient approach for certifying non-credit-bearing opportunities, noting that these fall outside of CoC’s purview but should be held to similarly high standards as for-credit classes.

Financially Sustaining MIT's Experiential Learning and Makerspace Ecosystem

Feedback from MIT community members has consistently emphasized the strength of MIT's existing landscape of experiential learning programs and makerspaces, but noted that these programs are often in precarious financial positions and many lack the resources to support all interested students. The message was clear: MIT should dedicate enough resources to ensure continued access to vibrant existing programs, rather than creating anything new.

To that end, TFUAP wants to reaffirm our belief that hands-on making and breaking, along with myriad forms of experiential learning, are a key part of what makes MIT's undergraduate education distinct and impactful. While not always required or even credit-bearing, these experiences are vital learning opportunities that should be treated as core to MIT's educational operations and funded accordingly. We recommend that forthcoming fundraising campaigns highlight makerspaces and experiential learning of all types so that future MIT students can continue to benefit from these opportunities.

Tracking Participation in Hands-on and Experiential Classes and Opportunities

Tracking student participation in hands-on and experiential classes and opportunities can help ensure equitable access to these opportunities, facilitate effective advising of students about which experiences can advance their learning and career goals, and support efficient allocation of central resources to programs and classes with excess student demand. TFUAP proposes that centralized tracking of hands-on and experiential learning be treated as an MIT-wide effort. While the decentralized nature of these programs at MIT has allowed unique and meaningful opportunities to proliferate across campus, it remains difficult to understand where demand for opportunities far outstrips supply or which populations might benefit from targeted outreach. With new student success tools on the horizon, TFUAP notes that it is a fortuitous moment to streamline student applications and tracking across many types of hands-on and experiential learning classes and programs. Co-curricular hands-on and experiential learning may lack a formal registration system, but if we believe it is a vital part of students' education, we should be tracking it consistently.

Creating such a system and ensuring consistent use by programs will require a concerted effort by many stakeholders, potentially including the Office of Experiential Learning, Registrar's Office, Institutional Research, Undergraduate Advising Center, and staff from individual programs, among others. TFUAP recommends that a working group of stakeholders convene in AY27 to determine the best approach.

2G: Supporting Mentoring Relationships Between Students and Faculty

Rationale

One of TFUAP's goals was to "provide meaningful mentoring relationships" (Process Goal 5). For students, these relationships serve many purposes, including career and academic advice, letters of recommendation, one-on-one instruction and guidance in the field, personal support, and introductions to academic and professional connections. Students form these relationships with faculty and instructors in many contexts, including classes, experiential learning opportunities such as UROPs, advising, and thesis work. In some settings, such as direct faculty supervision of a UROP student or interactions in a small seminar, these relationships develop almost inevitably. In other cases, such as lecture classes or UROPs in large labs where graduate students serve as UROP mentors, students must make a special effort to connect with faculty and instructors. This extra effort is part of the hidden curriculum of college, something that comes naturally to students with certain types of educational capital and that other students miss entirely.

We heard from the community that students and faculty alike appreciate the flexibility to form (or not form) these mentoring relationships organically across a variety of contexts, and to include graduate students as key players in undergraduates' mentoring networks. We also heard that undergraduate students want more support for making these relationships happen, particularly in ways that yield strong letters of recommendation from faculty and instructors.

Description

TFUAP proposes that a new process be developed for students to request brief draft letters of recommendation from faculty and instructors throughout their time at MIT. This process would be managed centrally to allow faculty and instructors to submit confidential letters. UAC advisors would inform students of this option early on, and reminders would be sent at the end of each term, with the goal of each student requesting 1-2 letters per year from faculty that they had gotten to know. To request a letter, students would have to submit a statement reflecting on what they had learned through their interactions with that faculty member (whether in a class, UROP, or other experience). This statement would be shared with the faculty member, who could then choose to accept the request or not. If they accept, the faculty member or instructor could use the student's reflection as a jumping-off point to write a brief (1-2 paragraphs) general-purpose note describing the student's performance in the relevant experience. Ideally, the system would include a mechanism to submit both a confidential note and a note with feedback to be shared with the student.

Students who later seek letters of recommendation for graduate school or other programs could then return to the faculty member or instructor who submitted draft letters. The faculty member or instructor could then use the draft letter as a starting point for a letter tailored to the application in question.

Process, Timing, and Oversight

Setting up this process will require coordination among staff offices (such as the UAC) that directly advise students and those that would manage the system for requesting and storing letters and faculty governance and departments who could get faculty buy-in. This could begin with a phased roll-out in specific departments and programs to test the processes involved and iterate before scaling to the full undergraduate population.

Special consideration would need to be paid to how many letters were requested per student and per faculty member, and the associated approval rates, to ensure that all students have equitable access to letters and faculty are not overburdened. While we hope that this can be managed through advising and departmental guidance to faculty, it may become necessary to set deadlines for requests and/or letter submissions, caps on letters per student, or other policies or limits to keep the system manageable and effective for all.

3: Policies

The collection of policy recommendations that follows addresses many parts of the undergraduate educational experience, including registration, classroom policies, and more. Each is designed to solve a problem that we heard from the MIT community through our listening tour and white papers. The overarching goals of these policy changes are:

1. Clarity: Increase transparency and reduce complexity whenever possible.
2. Commitment: Refocus the classroom environment on high-quality in-person learning.
3. Compassion: Reduce unnecessary stress for students, instructors, and advisors.

Many of these policies are designed to work in tandem and reflect our commitment to supporting both parties in the student-instructor relationship.

3A: Clarity

The following policies are meant to reduce uncertainty and complexity for both students and advisors by increasing transparency and eliminating a legacy rule that disparately impacts certain departments.

Abolishing Non-Overlap Guideline

Problem

We heard from at least one department that the "non-overlap" rules enforced by the Committee on Curricula (Section 10.4.1 in the CoC Guidelines) and codified in major degree charts harm students in their major. TFUAP feels that students should be given the freedom to double-count subjects for their majors and GIRs, provided that the subjects fully satisfy the learning objectives of both requirements.

Proposed Policy

TFUAP proposes removing Section 10.4.1 from the CoC Guidelines and instead allowing students to count subjects taken for any major or minor towards their GIR subjects if applicable.

Considerations

- TFUAP recommends preserving the intent of Section 10.4.2, which impacts the overall size of major programs, but revising it to reflect the constraints described in prior sections (majors may specify up to 12 units of GIR subjects beyond their 14.5 subject maximum *and* may require that students take 12-unit versions of up to 2 of the 4 Flexible Foundations GIRs).
- Students would still be expected to complete a total of 32 subjects (GIRs plus "units beyond the GIRs"), but may be able to allocate a larger portion to unrestricted electives.

Posting Syllabi

Problem

Students are often unaware of what a class entails when registering, and some will register for classes solely to access the Canvas site or syllabus, leading to confusion about which students genuinely intend to take the class and creating extra work for students, advisors, instructors, and anyone else involved in approving student registration.

Proposed Policy

When schedules are posted for the upcoming term, all subject listings (with limited exceptions for independent studies, special subjects not currently in use, etc.) must include a link to the latest class syllabus. For subjects that have been previously offered, this can be the syllabus from the most recent semester. For new subjects, this can be a draft syllabus. In either case, the linked syllabus should be updated to the current version no later than Add Date. Syllabi may be fully public or visible to anyone with MIT login credentials, but should be visible to all MIT students and employees.

Considerations

TFUAP recommends that the Registrar's Office, in consultation with faculty governance, should be responsible for deciding on where and how syllabi should be posted and informing departmental administrators and instructors about syllabus posting policies.

Interim Grade Reports

Problem

Students have shared that some instructors fail to return graded assignments or provide any information about grades until the last few weeks of the semester, leaving students with no time to drop the class or modify their performance if their grades are unexpectedly low.

Proposed Policy

All instructors will be expected to provide an interim grade report directly to students (via Canvas, website, or email) no later than one full week before Drop Date. At minimum, the grade report should entail a flag for students who are performing at a D-level or below (similar to current fifth-week flags for first-year students), indicating that they are at risk of failing, and a separate flag for students performing at a C-level. A more detailed grade report may include the current calculated grade based on graded assignments thus far, or a projected final grade based on demonstrated performance, and a narrative description of how the grade might change based on subsequent performance.

Instructors would also be required to return grades within a timely manner (e.g., within 2 weeks) to ensure that students have timely feedback on their performance.

Considerations

1. It may be appropriate to set a percentage of assignments (based on weighted point values) that must be included in interim grades. TFUAP has suggested 30-40% may be appropriate, but further study of syllabi and consultation with faculty is necessary to determine an appropriate number.
2. Insufficient or missing interim grade reports should be valid grounds for a late drop petition.

Simplifying Forms for Add, Drop, and Limited Enrollment

Problem

In discussing our proposed policies with instructors and students, concerns about the current processes for adding and dropping classes and getting spots in limited enrollment classes arose in discussions. Instructors in large classes felt overwhelmed by manually approving individual student forms. Instructors limiting the size of their classes for various reasons felt limited by the existing waitlist tools. Students and advisors felt confused about how and when limited enrollment class spots were allocated, creating extra stress in the first week of classes. And students also shared frustration that their forms were not approved in a timely manner or that there were too many unclear steps required.

These concerns generally reflected issues with systems rather than policies, but given their interactions with policies, we discuss them here.

Proposed Solution

TFUAP recommends that any new registration system adopted in the next few years include the following functions:

1. Batch approval of all types of student forms.
2. Automatic actions based on particular conditions. For example, an algorithmic process for admitting students into a limited enrollment class based on instructor-specified criteria (academic year, major, prior attempts to enroll, etc.). Or enabling an instructor to approve all add forms for a subject up through a particular week of the term. Or an instructor approving all double-booking requests for a subject. These are just a few common examples.
3. Clear and frequent communication to students about form statuses, criteria for admission to limited enrollment sections, and necessary actions.

Considerations

TFUAP recognizes that these improvements will likely require the adoption of a new registration system, but defer to the Registrar's Office in case these features make sense in a different system or could be implemented sooner.

3B: Commitment

The following policies are meant to ensure that both instructors and students commit to participating fully in an in-person learning environment. While many of these policies also support the goals of clarity and/or compassion by reducing uncertainty and therefore stress for students, instructors, and advisors, these policies are connected by their direct impact on how early and fully students and instructors commit to MIT classes.

Registration Timing

Problem

The current pre-registration has been in place for some time and carries both benefits and costs. Students frequently change their minds between pre-registration and registration, which undermines the accuracy of enrollment predictions used for faculty/TA allocation, classroom assignments, and resource planning. Students are often confused about the purpose of pre-registration and may approach it thinking it will help them secure a spot in certain classes, thinking it is purely for instructor planning purposes, or viewing it as a useless but necessary step to avoid being fined. There is also no expectation that students discuss their pre-registration with their advisor.

While pre-registration is not always well understood, many community members have noted the benefits of registering immediately before the term, such as additional information, like final grades or experiences during the summer or IAP, that inform students' choices. Some faculty, meanwhile, would prefer to spread the registration process over a longer period. However, many students consider late registration to be a beloved MIT tradition. Likewise, they shared challenges with a potential earlier registration, including making choices and scheduling advising meetings during the busy end of the semester or registering for sophomore fall classes before meeting with a major advisor. TFUAP had considered some of these challenges in our prior conversations, but were unaware of the diversity and intensity of community opinions on this topic.

Proposed Next Steps

In light of the mixed feedback from the community, TFUAP recommends further consideration by the Vice Chancellor for Graduate and Undergraduate Education and the Registrar before a specific policy is proposed. This process should include input from key stakeholders, including students, advisors, faculty, and administrators in a variety of departments, particularly those with small classes and unpredictable enrollment numbers. Specific issues that should be discussed include:

- Minimizing stress associated with the timing of Registration meetings and decisions
- Ensuring that first-year students have access to the limited enrollment subjects they need in the fall semester, particularly CI-H/HW subjects
- Prioritizing the ability for students and advisors to meet in person when possible and have substantive conversations
- Providing as much information as possible for both students and departments to plan ahead
- Maintaining the "shopping period" during the first week or so of classes, as students learn more about their subjects and add or drop accordingly
- Providing time for students and advisors to discuss and make choices based on final grades from the previous semester

Clarifying Expectations Around Drop Date

Problem

MIT has much later Add and Drop Dates than many, if not most, peer schools. While this allows flexibility for students, it can have a detrimental effect on classroom dynamics, particularly when groupwork is essential to the course. TFUAP also heard many anecdotes from advisors who recounted examples of students committing to too many classes and deciding late in the semester to drop one, when the student would likely have been better off committing to fewer classes from the start. The late drop date may benefit some very engaged students who push themselves to the brink and overcome adversity, and hurt those who are already struggling.

Based on this, TFUAP initially recommended moving the drop date to earlier in the semester. However, TFUAP has heard different perspectives from many students. Students have shared that having such a late Drop Date gives them freedom to take risks and to stick with classes when they struggle on a first assignment or midterm, knowing that they can take time to see if they can turn things around before dropping. Much like pre-registration, students see the late drop date as an essential feature of the MIT experience.

We obtained data from the Registrar that showed that drops in the later weeks (weeks 9-11) account for approximately 6-8 percent of all dropped classes (this is based on the self-reported "date last attended", not the date that the drop form was submitted). Data also showed that term GPAs of students who dropped in weeks 9-11 were ~0.3 GPA units lower than those of students who dropped earlier or did not drop a class. We conclude that drops in weeks 9-11 account for a relatively small number of drop decisions, and that it is unclear whether these later drops cause a lower term GPA or whether there are other reasons for the difference (for example, perhaps those students would have done even worse had they not dropped, or maybe they had health issues that disrupted their entire term, etc.).

Ultimately, given the mixed feedback from the community and the lack of causal evidence suggesting that students who drop classes after week 9 do worse in their other classes than they would have had they dropped earlier, TFUAP has decided not to recommend changing the Drop Date at this time. However, we still note that late drops negatively impact team members of students in project or team-based classes, so we recommend that clearer expectations of students be adopted in those contexts and clearly laid out in the syllabi.

Proposed Policy

TFUAP recommends that the current Drop Date remain in place, but that the Committee on the Undergraduate Program, the Committee on Academic Performance, or another group assess the extent to which dropping subjects late in the semester impacts student performance in other subjects. This assessment should include analysis by S^3 of their visit rates and discussion topics, which may provide a deeper understanding of how late drop impacts student stress, regardless of their final grades.

TFUAP also recommends that instructors of subjects with team-based assignments be encouraged to adopt syllabus statements informing students when their late drops will impact other students in the class. While students will still be allowed to drop up until Drop Date, instructors may list a "course-specific Drop Date." Example syllabus language:

[SUBJECT #] is a project-based course [AND/OR INCLUDE OTHER/ADDITIONAL DESCRIPTOR(S)]. You will be working in a team to [PROJECT GOAL/DELIVERABLE]. Your active engagement is critical to your learning in the class and to your team's success in achieving the project goals. In particular, your disengagement with the course will affect not only you, but also your teammates. Waiting to drop the course until Drop Date [INCLUDE THE OFFICIAL DROP DATE OF THE RELEVANT SEMESTER] will seriously undermine the work of your peers and the efficacy of the team.

Therefore, the deadline for dropping this course is [COURSE DROP DATE (e.g., Friday of week 9)]. Failure to drop before this date, for reasons that existed before this date, places an unfair burden on your peers.

I am happy to meet with you to discuss your progress in the course and/or your potential decision to drop. Please reach out to me [CONTACT PREFERENCE(S)] anytime before [DATE BEFORE COURSE DROP DATE]. This will allow me to create and support the learning and teamwork experiences of the students who remain in the course, and will give you the opportunity to better focus your learning in your remaining subjects.

Scheduling and Double-Booking

Problem

Roughly 15% of students (see Appendix D) in any given semester are registered for at least two subjects that meet at the same time. This behavior, known as "double-booking," appears to be an MIT idiosyncrasy. Double booking is perceived as a right by students, who point to the need to double-book classes when double-majoring, or when certain classes in a pre-req chain are offered infrequently, or for classes whose material they already know but for which there is no ASE, or simply as the prerogative of an adult making choices about how to spend their time.

In contrast, instructors have shared concerns about double-booking, noting negative impacts on the classroom environment and student learning. Currently, many instructors are unaware that a student in their class is double-booked until the student asks for support or accommodation for exams that meet at the same time, and instructors vary in their ability and willingness to accommodate such requests.

Across the Institute, a variety of policies exist regarding double-booking. Some Schools, like Sloan, prohibit it. Some departments, like Math, have an explicit policy that no accommodations will be made for double-booked students. And some subjects have attendance policies that enact a penalty (up to failing) for students who do not attend their class (due to, for example, double booking).

Especially after the COVID-19 experience of remote learning, the current fears surrounding generative AI's impact on learning, and the emerging consensus that the skills that will be most valued in the labor market are the ability to engage, collaborate, and work with other people, TFUAP strongly feels that MIT must re-center around in-person education, with students present in class and paying attention. And we note that, even at MIT, students cannot be in two places at once. In addition, far from being infantilizing, learning to not make mutually incompatible commitments is an essential preparation for life as adults.

We thus propose scheduling and policy changes to lessen the need to double-book, and then to make double-booking the *exception*, not the norm.

One reason for double-booking is that scheduling is highly distributed across departments and instructors, with little or no coordination to minimize conflicts for students. A symptom of this distributed scheduling is the large variety of time blocks used for courses. Although the Registrar's Office recommends a set of standard time blocks for lectures (MWF for one hour starting on the hour, or TR for 1.5 hours starting at 9:30, 11, 1, or 2:30), more than 50% of three-hour-per-week lecture subjects don't use these time slots at all (see Appendix D). A subject that meets at an unconventional time, such as TR10-11:30, overlaps with two conventional time blocks, creating additional conflicts for enrolled students and leaving classroom space empty before and after class time.

Proposed Policy

1. Revised scheduling blocks: To effectively address the double-booking problem, MIT should schedule subjects deliberately to minimize conflicts between subjects that students want to take in the same semester.

   First, all classes must be scheduled within standard time blocks, which will be determined by the Registrar’s Office to include an appropriate number of hour-long and hour-and-a-half-long blocks. Classes that need to be longer for pedagogical reasons can use a combination of consecutive blocks, provided that they submit a rationale. Recitations and labs will be encouraged to use standard time blocks, but will only be required to do so if students do not have multiple section times to choose from.

   In addition, the Registrar's Office will make data available to departments and instructors to help them choose times that reduce conflicts, such as historical co-registration (number of students taking subject A and subject B in the same semester) as well as *desired* co-registration (students preregistering for A and B, but forced to take only one in the end to avoid double-booking).

2. Monitoring and notification: As soon as technically feasible, MIT should begin tracking rates of double-booking and notifying instructors of all students in their classes who are double-booked. Instructors will not be required to take any action, but may choose to reach out to the listed students to clarify what accommodations will and will not be

provided based on scheduling conflicts.

3. New process for double-booking: After the new scheduling policy has been in place for at least two years, MIT will limit the practice of "double-booking" classes for all undergraduate students. Instructors will designate classes as either "double-booking prohibited," "double-booking allowed," or "double-booking by petition." These designations allow students and instructors to avoid a petition process in classes where it makes sense to have a blanket policy. If petitions are required, students can petition to double-book classes and will be allowed to do so if their advisor supports the student's rationale for double-booking, and if the primary instructors for each conflicting class support the student's plan of how they will manage the conflict.

Considerations

1. Any scheduling policy should be assessed to ensure that conflicts do not get worse and to monitor unforeseen impacts. Decisions about time blocks should be made by a combination of Registrar's Office staff and faculty governance.
2. MIT's current registration system cannot prevent double-booking. Should this policy be adopted, formal enforcement cannot be done until a new registration system is in place. TFUAP recommends that the capacity to flag, disallow, petition, and override the double-booking policy should be included in whatever registration system MIT adopts.
3. After implementing the petition process for double-booking, MIT should monitor the petitions submitted to see if common conflicts can be resolved by modifying schedules.
4. In cases where students try to double-book subjects with different policies (e.g., one subject prohibits double-booking and the other allows it), students should have the ability to attest that they will fully attend the subject that bans double-booking and skip the subject that allows it, bypassing the need for instructors to review a petition.

Resetting Classroom Expectations

Problem

There is a widespread sense that student engagement in their academic experience has decreased substantially in recent years. As we noted, at MIT, double-booking of classes is common; instructors report that classroom attendance has decreased, and students in many classes acknowledge that they are multitasking on their phones and laptops rather than engaging in learning. This behavior is not restricted to the post-pandemic era, and is not unique to MIT (for example, Harvard, the Chronicle of Higher Education, a review in the *Int J. Ed Res.*).

Students are in residence at MIT because we believe there is value in *in-person learning*. Much learning and personal growth occur in the dorms and FSILGs. But learning, and its counterpart inspiration, also occur in class, and student attendance and engagement in class are pivotal for a residential campus.

This pilot program and policy are intended to nudge the MIT culture back toward a focus on the academic experience by resetting the norms while allowing flexibility. Importantly, we believe that both students *and* instructors need to step up; the relationship between them needs to change, not that a single party is entirely responsible for the state of affairs. Instructors thus need to incorporate pedagogical practices that make the classroom an engaging, educationally valuable place to be.

In many subjects, the current norm is not to require attendance and to allow unfettered use of electronic devices, so the lone instructor who deviates from this norm is at risk of being punished (or is worried they will be punished) in the course evaluations or by decreased student enrollment in their subject. Below, we propose an "Engaged Classroom" pilot that sets new expectations for both students and instructors. We also propose a smaller selection of new and reaffirmed classroom norms for all subjects. Instructors would choose whether to participate in the pilot, and any student taking an "Engaged Classroom" subject would be expected to abide by the norms described below. We thus wish to establish a new baseline and recognize the instructors who choose to go above and beyond in order to change the MIT culture through strength in numbers.

The proposed pilot is modeled on policies used in MIT Sloan and informed by best practices from Harvard's Derek Bok Center for Teaching and Learning and a series of articles in the Chronicle on Higher Education. It also reflects research[9] describing the detrimental impacts of multitasking on learning.

Proposed Pilot and New Norms

In order to create a productive learning environment and ensure mutual respect, it is essential that the norms of classroom etiquette and behavior reflect the highest standards. It is also important that a commitment to an effective in-person learning environment be upheld by both instructors and students.

New Norms in All Subjects

Some classroom norms are non-negotiable, such as a commitment to academic integrity, an expectation that the typical required weekly hours for a semester-long subject roughly matches the subject units (i.e., a 12-unit subject requires ~12 hours per week), or the expectation that instructors follow "MIT time" (starting 5 minutes after the nominal start time and ending 5 minutes before the nominal end time) to provide students with time to move from one class to the next. In addition to these existing norms, we propose that all classrooms be treated as screen-free environments unless instructors explicitly allow devices (as noted on syllabi). This will require a

[9] Multitasking: Switching costs: Subtle "switching" costs cut efficiency, raise risk. American Psychological Association; Basak, C., & Verhaeghen, P. (2011). Three layers of working memory: Focus-switch costs and retrieval dynamics as revealed by the N-count task. Journal of Cognitive Psychology, 23(2), 204–219.; Multitasking? Maybe Not (2025). Wake Forest News.

new baseline assumption from students on the first day of class, but we expect it will be easier to achieve low-screen or no-screen learning environments if instructors must opt in to allowing screens rather than opting out.

Engaged Classroom Pilot

Beyond these norms, we propose an opt-in (by faculty) pilot that takes a few extra steps. The use of a pilot creates flexibility for instructors while ensuring that instructors who opt in uphold their end of the deal.

Subjects in the "Engaged Classroom" pilot would have additional expectations:

- Students arrive on time (following "MIT Time") and stay for the entire class (see also *Scheduling and Double Booking* policy).
- Students attend all classes. Instructors may choose how to enforce or grade attendance/participation.
- Laptops, tablets, and phones remain closed/off except when explicitly allowed by the instructor, such as during class segments when this technology is used as part of the instructional program, or allowed as part of a DAS student accommodation.
- Instructors will adopt pedagogical practices that ensure that each classroom session adds educational value beyond what is offered in online course materials. See the Active Learning section, below, as well as the Teaching + Learning Lab's resource pages on high-impact teaching and learning strategies and active learning research. To be certified as an "Engaged Classroom" subject, instructors must describe the pedagogical practices they plan to use and be certified by their department's education committee.
- Engaged Classroom subjects will be noted as such in the subject listing and schedule.
- Choosing to teach an "Engaged Classroom" subject will be noted favorably on faculty personnel records and may serve as a contributing factor in teaching awards and education-related grant programs.
- Instructors can be encouraged to develop strategies for "Engaged Classroom" subjects as part of course development funds, such as the d'Arbeloff Fund.

It is expected that faculty will articulate at the start of the term how these expectations apply in their subject and how they will be enforced. Students who believe that instructors are violating policies as outlined in the subject syllabus should reach out to the department's undergraduate officer (or other designated individual).

Adopting Active Learning Practices

As noted by Felder & Brent in *Teaching and Learning STEM: A Practical Guide, Ch. 6.* San Francisco: Jossey-Bass (2016)*, p.112:*

> *"A good traditional lecture can certainly serve several useful purposes, including sparking interest in the lecture topic, raising questions and provoking subsequent discussion, and filling in gaps in people's knowledge when they already understand most of the lecture content. However…[t]he only way a skill is developed---diving, writing, critical thinking,*

> *deducing biochemical pathways, or solving dynamics problems—-is through practice: trying something, seeing how it works, possibly getting feedback, reflecting on how to do it better, and trying again…"*

Of course, out-of-class assignments (psets, projects, etc.) play a key role in this learning. However, the use of active learning strategies (targeted opportunities for students to apply concepts and ideas, and to confront misconceptions with timely support from an expert *during* class) has been shown to be effective and necessary for promoting deep and enduring understanding—especially for higher-order cognitive skills and knowledge. See Appendix E and TLL's page of selected active learning research.

In addition, the inclusion of more active engagement opportunities during class necessarily shifts the focus from information *delivery* (the instructor's job) to information *processing and knowledge creation* (the student's responsibility). Active learning classrooms are, by design, places where instructors and students are partners in the learning process.

Considerations

Dissemination

Proper dissemination is integral to widespread adoption. First, the President or Chancellor should send a message to the entire MIT community announcing the norms and pilot. Second, students should be made aware of the existence of the norms and pilot during orientation or via their UAC advisor. Third, instructors should be made aware of the norms and pilot during New Faculty Orientation or other onboarding procedures. Department leadership should also be enlisted on an ongoing basis to encourage faculty to participate.

We worked with Open Learning to try to estimate the number of classes that might participate in the "Engaged Classroom" pilot. They found that of the ~2500 active Canvas class sites in AY25-26, ~700 mentioned "attendance" in their syllabus, and of those, several hundred subjects indicated that attendance was graded, expected, or similar language. We note that some subjects (such as many in EECS) use different learning management systems, while other subjects may discuss attendance elsewhere than in the syllabus. In addition, not all sites that mention attendance would necessarily opt into the "Engaged Classroom" pilot, while other classes may now be empowered to do so. Thus, the ultimate number of classes that will opt in is not known, but it is likely, based on this data, to be in the hundreds.

3C: Compassion

The following policies are designed to reduce unnecessary stress around both high-stress times (final exams) and holidays meant to give students and instructors a break.

Replacing Fall Registration Day with a Holiday on the Wednesday before Thanksgiving

Problem

Students and faculty have shared concerns regarding Thanksgiving travel, noting that having class the day before Thanksgiving can make it logistically or financially impossible to visit family out of state without missing classes.

Proposed policy

Fall semester classes would begin on the Tuesday following Labor Day, turning the current Registration Day into a regular class day. The Wednesday before Thanksgiving would become a student holiday, with no classes held.

Considerations

1. This shift is easiest if Registration Timing (Section 3C) is moved earlier so that students can meet with their advisors during the prior term rather than on Registration Day. However, it can also be accommodated by asking advisors to meet with students to register for classes during the week preceding the first day of classes. Given that many students and advisors are not yet on campus during that week, many of these meetings would need to be conducted virtually. Alternatively, advisors could meet with students in person in the spring to discuss classes and then register asynchronously when registration opens in August.
2. Depending on the resulting distribution of class days, there may need to be a day when, for example, Monday classes are held on a Tuesday (perhaps after Indigenous Peoples' Day), similar to what is done following the Presidents' Day holiday.

Restricting Assignment Due Dates

Problem

Some instructors make assignments due on holidays or during/shortly after a major break, often cutting into students' time off. This manifests as de facto requirements that students work when they should have time away from academics.

Proposed Policy

Require that assignment due dates do not fall on a student holiday, the day before Thanksgiving, or the first business day after Thanksgiving or Spring Break.

Considerations

We recognize that this may lead to some compression of due dates in the days prior to breaks and later in the week after a break. Instructors are encouraged, but not required, to give students advanced notice of assignments and/or additional cushion around breaks to enable students to schedule work time and break time effectively.

Increasing Preparation Time for Finals

Problem

Some finals, particularly in the spring semester, fall only 3 days after the last day of classes. This often does not provide students sufficient time to prepare for finals. While we recognize that the academic calendar is highly constrained, there is a need to ease some of the pressure on students at the end of the spring semester.

Proposed Policy

To align the spring semester's last test date with the fall semester, the last test date should change from being the Friday before the start of the reading period (as specified in the Faculty Rules and Regulations) to whatever day is 5 calendar days before the last day of classes. If this date falls during a weekend, the last test date will be the Friday before said weekend. Using the spring 2026 semester as an example, this would push the last test date from Friday to Thursday.

Considerations

Depending on how instructors choose to move their deadlines, this may lead to compression of deadlines on the last Thursday in the spring term.

4: Pedagogy

Expectation of high-quality instruction and a multi-year effort by the Teaching + Learning Lab and Open Learning -Residential Education to improve pedagogy

Student understanding and growth, and indeed, their learning in any single GIR can and should be supported, reinforced, and at times challenged by their learning in other GIRs. In our reimagining of the GIRs, we recognize this opportunity and provide the following recommendations for a pedagogical initiative that embodies a commitment to the shared responsibility and vitality of the GIRs [Soicher]. The foundations of this initiative are the experiences and deep disciplinary knowledge of MIT faculty and lecturers, informed and modulated by the needs and interests of GIR home departments. The initiative brings together faculty and lecturers to explore how they can use the principles from the science of learning together with evidence-based teaching practices to support the design and delivery of individual GIR subjects. It facilitates intentional and meaningful connections across instructors, content, and pedagogy across these key subjects.

Support for the Design → Delivery → Analysis of New GIRs

Instructors of all new GIR subjects will be encouraged to participate in a multi-year, cyclical process of Redesign, Delivery, and Analysis—built on their disciplinary expertise—with support from the Teaching + Learning Lab (TLL), Open Learning Residential Education (OL-Res), and Open Learning's Disciplinary Experts in Learning Technology and Applications (DELTA) team (formerly Digital Learning Lab scientists & fellows [DLLs]). The participation of instructors from the first-year learning communities—ESG, Terrascope, Concourse, and DesignPlus—would also be encouraged and valued. This process will be grounded in the science of learning, evidence-based subject design and teaching, and classroom-based educational research. It provides incentives for individual faculty and departmental participation and creates structured opportunities for all GIR instructors to come together to build connections to enrich teaching and learning across the GIRs.

This initiative brings together faculty, lecturers, and instructional teams for the GIRs and staff from the Teaching + Learning Lab and Open Learning - Residential Education, and Open Learning DELTA, and includes 3 key components:

- Course Adaptation & Design Institute (CADI), offered annually in early June
- Subject Support Teams (SSTs) for each new GIR
- Inter-Subject Community of Practice

Each of these components is described below.

Course Adaptation & Design Institute (CADI)

Instructors in new or revised GIR subjects, preferably in teams of 2-4 instructors per subject, will participate in a week of workshops in early June. Participants will have time in the workshops to work on course plans and revisions.

Facilitated by staff from TLL, OL-Res, and OL-DELTA, participants in CADI will use the Backward Design[10] to:

- Develop subject-specific learning outcomes that align with the programmatic learning outcomes and TFUAP learning and process goals (as accepted by the MIT faculty).
- Create student assignments that meaningfully assess student learning (or progress toward articulated learning outcomes) and engage students in individual critical thinking and collaborative problem-solving. This will include considerations of GAI-aware assignments, assessments, and in-class work.
- Plan in-class teaching and learning activities that leverage the science of learning and evidence-based teaching practices to engage students and provide opportunities for deeper learning and more enduring understanding.
- Collaboratively discuss (with TLL research and evaluation experts) how to define success with respect to the reimagined subject.

[10] Wiggins, G., & McTighe, J. (2005). Understanding by Design (Expanded 2nd ed.). Alexandria, Virginia: Association for Supervision and Curriculum Development

- Develop plans to assess the impact and effectiveness of specific course design and delivery choices through the collection and analysis of relevant data, with the goal of informing and improving future iterations of the subject. Data sources may include syllabus/assignment analysis, classroom observations, instructor interviews, and/or student surveys & interviews.

CADI will emphasize evidence-based teaching techniques and therefore, will support nearly all of the TFUAP goals, including:

- Peer collaboration (Learning Goal #4)
- Scaffolding communication skills (Learning Goal #5)
- Critical thinking (Learning Goal #6)
- Relevance (Learning Goal #8)
- Peer support and community (Process Goal #1)
- Experiential learning (Process Goal #2)

As previously stated, all work in the CADI is founded on the knowledge and expertise of MIT faculty and instructors, informed by the needs and constraints of their departments and the MIT community, with support from TLL, OL-Res, and OL-DELTA.

Subject Support Teams (SSTs)

If requested, a new GIR subject will be assigned a Subject Support Team (SST) that includes staff from OL and TLL. SSTs will be available to support GIR faculty and instructors throughout the Design-Delivery-Analysis process. SSTs can assist in course planning, assessment design, the selection and use of in-class teaching and learning strategies, and follow-up subject assessments. They can also provide resources and workshops for TAs, and engage in collaborative discussions with the instructional teams about the data collection and analysis processes.

Inter-subject Community of Practice (ISCoP)

As stated in Tomasik, *"...a community of practice of GIR instructors will better coordinate the science core GIRs, provide more opportunities for instructor and student community building, train students in how to learn, increase the use of evidence-based teaching practices...and study the results of interventions for cycles of iterative change."*

In advance of each academic year, all new GIR faculty and lecturers will be invited to participate in the Inter-subject Community of Practice (ISCoP)

ISCoP will meet 2-3 times/ semester and 1 time each during IAP and Summer. It is designed to:

- Foster coordination and collaboration of GIR instructional staff across the institute
- Support the cross-subject reinforcement of key concepts in GIRs and the development of interdisciplinary teaching opportunities to enrich student learning
- Identify opportunities for concurrent presentation of shared content
- Provide a venue to compare and discuss subject policies (exam, grading, etc),

- Enable consistent application of the science of learning and research-based practices across GIRs
- Provide opportunities for discussion of successes and challenges in new GIR subjects, and to discuss options for future iterations (including potential opportunities for future/more robust collaboration)

ISCoP meetings will be facilitated by staff from TLL and OL.

Pedagogical Support for All Instructors

In addition to the initiatives for GIR instructors, described above, increased support for the design, delivery, and analysis of MIT subjects will also be available to all members of the MIT teaching community. These efforts will include:

- Course Adaptation & Design Institutes (CADI), offered in early summer
- School-based New Faculty & Lecturer Cohorts, modeled after TLL's Kaufman Teaching Certificate Program
- Topic-based Faculty Cohorts, with topics based on faculty interest. See this poster for a summary of work from a past AAU-funded Evidence-based Teaching Cohort
- Departmental Action Teams to support substantive, instructor-driven change at the departmental level.
- One-on-One Consultations with a TLL Research & Evaluation team member to:
  - Discuss course design, delivery and assessment
  - Develop purposeful, measurable research questions and objectives
  - Design a study to address educational research questions and objectives
  - Collect and organize pertinent data
  - Analyze collected data using relevant and rigorous analytic approaches.
  - Interpret the findings to guide future decision-making.
- Resources and one-on-one support for the effective use of research-based teaching strategies.

Funding Considerations

Teaching Postdocs

The success of this initiative requires the hiring of teaching postdocs or graduate students in designated departments. These individuals will bring both expertise in the discipline and at least one additional skill in: learning sciences, learning analytics, curriculum and educational research, or in another relevant area. Funding for these positions would be shared by home departments and MIT. (Barnes)

Teaching postdocs are modeled after Open Learning's highly successful Digital Learning Fellows program (recently reconfigured as DELTA), which supports digital teaching and learning (among other things) within departments.

GIR Faculty & Lecturer Participants

Participating faculty and lecturers will be provided with discretionary funds and/or teaching relief during the first two years of the Design-Delivery-Analysis phase of the initiative.

Note: references and supporting materials for this section can be found in [Appendix E](#).

Supporting Interdisciplinary Teaching

> *"True interdisciplinary teaching goes beyond just putting different topics side by side. … it means weaving ideas, theories, and methods from many fields to examine a shared theme or question. This takes careful planning, a willingness to step outside your comfort zone, and a focus on working together. The aim is not to water down each subject but to strengthen them by showing how different ways of thinking can shed more light on tricky issues…"*
>
> Hojiej, Z. (2025). Practical Strategies for Interdisciplinary Teaching in Today's University, *Faculty Focus*, 18 July.

Interdisciplinary Teaching Fund

The new flexible foundation subjects will hopefully encourage the creation of multidisciplinary teams, but we believe more will be needed to change a culture that is highly siloed (not just at MIT). TFUAP recommends the creation of a new fund specifically dedicated to supporting interdisciplinary classes involving instructors from at least two (and ideally three or more) departments. Applications to and administration of this fund would be similar to the Education Innovation Funds for Teaching and Learning or d'Arbeloff Fund, with a few noteworthy differences:

1. Applications to the fund must include instructors and corresponding letters of support from two (and ideally three or more) separate departments.
2. Applications should describe a plan for sustained offering of the subject after central support ends, such as through dedicating instructor time, TA, and other support, and incorporation into the majors of the offering departments.
3. Recipients would receive sufficient support to run the subject for at least three offerings, which may occur at any time within 6 years.
4. In addition to funding to support the development of the class itself, funding will be awarded to the instructors' home departments in exchange for the time the instructor spends teaching outside their department. Funding may be used to hire lecturers, TAs, or other teaching support as needed.

Interdisciplinary Connections in the GIRs

The first year at MIT, before students become locked into a single discipline, department, and/or program and their discipline-specific methods for analysis and problem-solving, is a prime time to introduce students to interdisciplinary subjects. By engaging with interdisciplinary ways of thinking in the GIRs, students are better positioned to use multiple lenses and approaches to take on the complex problems and issues they encounter in more advanced courses in their chosen disciplines. See Newell, W.H. (1990, p. 79) for additional information.

The new proposed GIRs move away from traditional disciplinary siloes in multiple ways. The options for integrated flavors of science GIRs, Probability, Statistics, and Machine Learning GIR, and some anticipated Moral and Civic Perspectives subjects will all be interdisciplinary by design.

In addition to these structural approaches to engaging students in interdisciplinary learning, TFUAP expects the curriculum for the new SMC GIRs and Moral and Civic Perspectives classes to be developed with deliberate attention paid to connections among the subjects. This should involve reinforcing pre- or co-requisite subjects (e.g., relying on skills learned in the Computation GIR in other SMC subjects) as well as embedding explicit cross-references in subjects that students may take in either order (e.g., using Chem/Bio concepts to illustrate ethical questions raised in a Moral and Civic Perspectives class and describing the moral and social questions raised by a particular scientific discovery as it is introduced in the Chem/Bio GIR).

5: Governance

Given the relative infrequency of large-scale reviews of the undergraduate academic program and rapid advances in science and technology, including the rise of generative artificial intelligence, that impact what and how MIT students learn, TFUAP feels strongly that a more robust and nimble governance structure is necessary. The next curricular review should not wait 20 years, should not require such an extensive process, and should be based on better data. Giving the Institute the means to adapt more flexibly in the future should also reduce the stakes associated with any particular effort at curricular review (this one or any future one). To that end, we propose new ad hoc subcommittees and new responsibilities for existing (sub)committees to oversee the ongoing evolution of the GIRs to ensure they respond to changing needs and capabilities while maintaining fidelity to the original goals. This committee structure will also ensure that there is a more widely shared governance and that all spheres of expertise are represented. We also acknowledge that these changes will require additional staffing and updated norms and expectations for committee chairs and members. This may include additional onboarding and offboarding, increased meeting frequency, and more substantial work outside of scheduled meeting times.

New Ad Hoc Curricular Subcommittees

To oversee the creation and ongoing evaluation and iteration of the SMC GIRs, the Teamwork-Intensive Requirement, and the MCP Requirement, TFUAP proposes the creation of four new ad hoc subcommittees of the Committee on the Undergraduate Program (CUP), which may eventually become 2-4 permanent subcommittees of CUP. These subcommittees would join existing CUP subcommittees, such as the Subcommittee on the HASS Requirement (SHR) and the Subcommittee on the Communications Requirement (SOCR).

The four ad hoc subcommittees would focus on:

- The Science, Math, and Computing requirement
- The Probability, Statistics, and Machine Learning requirement
- The Teamwork-Intensive requirement
- The Moral and Civic Perspectives requirement

Each subcommittee would begin on an ad hoc basis and focus on defining and implementing the new requirements. Following an initial 3 year startup period, the faculty officers and CUP will coordinate to define and charge permanent subcommittees to oversee long-term maintenance of these requirements. The permanent structure may also include four subcommittees with the same areas of focus (totalling six subcommittees of CUP alongside SHR and SOCR), or PSM could be absorbed into the SMC subcommittee and MCP could be absorbed into SHR.

Faculty Rules and Regulations would be changed to enable flexibility for an initial 3-year period. During this period, all ad hoc subcommittees would act with power to approve subjects that count within a set of topic areas approved by the faculty. At the end of this period, the SMC and PSM subcommittees would suggest changes to Rules and Regulations to reinstate subject numbers into the SMC GIR section. Future changes to SMC requirements significant enough to warrant a new subject description would be approved by the subcommittee as well as CoC. Changes to SMC requirements requiring a new subject number would require a faculty vote, as is currently done. Subcommittees would continue to act with power to approve subjects that satisfy HASS, MCP, TI, and CI requirements.

The core functions and membership for the new ad hoc subcommittees are described below. In addition to the specific members listed, every proposed subcommittee would have a faculty chair, a non-voting staff member, and two undergraduate students.

Ad Hoc Subcommittee on the SMC Requirements

The ad hoc subcommittee would be charged with:

- Working with relevant departments to define learning outcomes for each SMC GIR at the 6-unit (for the flexible foundations) and 12-unit (for the common foundations) levels.
- Developing written criteria and a process for certifying subjects for SMC GIR credit. New SMC subjects should be challenging but not impossible to create, and the SMC committee will have to set the criteria accordingly. Additionally, in considering whether to allow a new subject proposal, the SMC committee would consult disciplinary committees (e.g., disciplinary Undergraduate Education Committees in the case of science and Mathematics subjects; The Common Ground in the case of a new computing subject).
- Recommending existing, revised, and newly created SMC subjects for approval by CoC.

- Working with the Vice Chancellor for Graduate and Undergraduate Education to incentivize and facilitate the creation of integrated GIR subjects between Flexible foundations disciplines.
- Determining whether and how AP/IB and ASE credit can be used to satisfy the SMC GIRs.
- Coordinating with the PSM requirement subcommittee as appropriate.

Membership would include representatives from units teaching the SMC GIRs and representatives from each of the schools, including:

- Representatives from disciplines: Undergraduate Officers from Biology, Chemistry, Mathematics, Materials Science, and Physics (or their designees); co-chair of the Common Ground (or their designee)
- The chair of the Ad Hoc Subcommittee on the PSM requirement
- 1 additional representative from each school and the college

Ad Hoc Subcommittee on the PSM Requirement

The ad hoc subcommittee would be charged with:

- Working with relevant departments to define learning outcomes for the PSM requirement.
- Developing written criteria for approving new PSM subjects.
- Recommending existing, revised, and newly created PSM subjects for approval by CoC.
- Coordinating with the SMC requirements subcommittee as appropriate.

Given that probability, statistics, and machine learning are taught in several departments across most, if not all, schools at MIT, this subcommittee is distinct in kind from the rest of the SMC requirements, necessitating specific representation from individuals who can speak to the different disciplinary approaches to these topics, including:

- 1 Faculty representative from each of the five schools and the college

Ad Hoc Subcommittee on the Teamwork-Intensive Requirement

The ad hoc subcommittee would be charged with:

- Working with experts on teaching teamwork and reviewing relevant literature to define a set of learning outcomes for all TI subjects.
- Developing written criteria for approving new TI subjects.
- Coordinating with departments to adapt existing subjects and create new subjects focused on teamwork.
- Recommending existing, revised, and newly created TI subjects for approval by CoC.

Given that teamwork is expected to be primarily taught within majors, this subcommittee should include representatives who can speak to the different disciplinary approaches to teaching teamwork, including:

- 1 Faculty representative from each of the five schools

Ad Hoc Subcommittee on the Moral and Civic Perspectives Requirement

The ad hoc subcommittee would be charged with:

- Working with experts on teaching moral and civic perspectives topics and reviewing relevant literature to define a set of learning outcomes for all MCP subjects.
- Developing written criteria for approving new MCP subjects.
- Coordinating with departments to adapt existing subjects and create new subjects focused on moral and civic perspectives.
- Recommending existing, revised, and newly created MCP subjects for approval by SHR and CoC.

Membership should include faculty with experience teaching moral and civic perspectives topics in a HASS context and considering moral and civic questions in the context of science and engineering, including:

- 1 Faculty representative from each of the five schools
- 1-2 additional representatives from SHASS

New Responsibilities for Existing (Sub)committees

Committee on the Undergraduate Program (CUP)

As part of its oversight of the undergraduate program, TFUAP recommends that the CUP write a report to the faculty every five years on the state of the program. The report should address:

1. The overall state of the undergraduate program and trends in departmental programs.
2. A review of the GIRs.
3. Opportunities for positive changes in the program as a whole, the GIRs, or pedagogy.
4. An overview of any areas of concern.

Committee on Curricula (CoC)

In addition to their existing tasks, TFUAP recommends that the CoC conduct a semesterly audit of hours spent on classes to ensure that the expected workload aligns with the subject units. For example, CoC may decide that any subject where the reported hours on student subject evaluations differed by more than 40% of the listed units would be flagged for review (e.g., a 12-unit class where the average reported hours were <7.2 or >16.8). The CoC would then choose to issue a notice to the instructor (recommended for first-time offenses or low response rates) or provide notice to the department that unless the subject is recalibrated in the subsequent semester, the units listed would need to be changed.

Subcommittee on the Communications Requirement (SOCR)

As part of their regular duties, TFUAP recommends that SOCR oversee limited experiments in CI subjects and recommend changes to the CI guidelines as outlined in the CI section above. They would be expected to report to CUP as usual and collaborate with other committees, including the Task Force on AI in Teaching and Learning, as appropriate.

Subcommittee on the HASS Requirement (SHR)

After the initial development phase, SHR may take on responsibility for certifying subjects that meet the Moral and Civic Perspectives (MCP) requirement as outlined in the HASS section above. If, instead, the MCP subcommittee continues to exist, SHR should also collaborate with it on an ongoing basis to assess the effectiveness of the requirement and ensure that the implementation of MCP is aligned with the goals of the remainder of the HASS requirement.

6: Directions for Further Efforts

Grading

Over the past decade, grading has been a central focus of many CUP discussions, leading to the creation and continued monitoring of the current Flexible P/NR policy. Likewise, national conversations concerning patterns of "grade inflation" have prompted study of MIT's own patterns of grade distributions. What is clear is that there has been what we call "grade compression," whereby grades are less distributed across the spectrum and instead concentrate in the A and B ranges. However, we have not seen evidence that standards are falling, and a variety of credible hypotheses for why grade compression has occurred have been proposed. Such hypotheses include those, such as more selective admissions and more effective teaching, that would suggest that the grades accurately measure improved average performance.

Regardless of the causes, grade compression has downsides, including the challenges of identifying excellence among students and the perception of many students that anything less than an A is considered failure.

After discussing the topic of grading on several occasions, TFUAP concluded that the topic demanded more time and attention than we could feasibly provide, given our other goals. Therefore, we recommend that a task force be created to study and propose new policies and practices on grading.

While faculty governance should determine the exact format, charge, and timeline for the task force, we recommend that membership include faculty from all Schools and the College, student representatives, and at least one staff member from the Teaching and Learning Lab with expertise on the latest research around grading.

The task force should consider the following questions:

1. How do internal and external stakeholders, including students, faculty, employers, and graduate schools, interpret MIT's current grades?

2. How does the grading system impact student behavior in their classes?
3. What new policies might motivate students and reward beneficial learning behaviors while reducing stress?
4. What new policies might reward and distinguish “excellence” without compromising MIT’s collaborative (rather than competitive) student culture?

Any proposed policies should be considered for their impacts on our students’ ability to get into top-tier graduate schools, including medical schools, as well as their impacts on student stress, motivation, and learning behaviors. Proposals may include both institute-wide policies (such as first-semester P/NR) and support for subject-based approaches that instructors could choose to adopt if they wished (such as specifications grading).

AI in Teaching and Learning

It is nearly impossible to discuss education in 2026 without discussing AI generally and generative AI in particular, given the profound impact it has had in the past few years on both what and how students learn. AI has come up in many TFUAP discussions, both internally and with MIT community members, and the consensus within TFUAP has consistently been that whatever we propose must be flexible and resilient enough to adapt to the dramatic changes that are likely ahead.

Our approach to AI is best described through the advance, align, and adapt framework that TFUAP has adopted to describe our overall set of recommendations. The new computing and probability, statistics, and machine learning requirements will advance the curriculum to ensure that all students understand the technical fundamentals underpinning the development of AI, and we expect that both requirements will evolve to both utilize and explain cutting-edge AI technology. Our approach to the HASS and CI requirements aligns MIT’s curriculum with the learning goals TFUAP feels will be more important than ever in the AI age, such as critical reading, effective communication, and a moral, ethical, and civic framework. Furthermore, we have challenged SOCR to experiment and ensure that the methods of communication our students learn are those that will remain relevant.

And finally, knowing that we cannot predict the future of AI, we have proposed that an ongoing governance body build on the initial work of the ad hoc Committee on AI Use in Teaching, Learning, and Research Training to help MIT’s educational apparatus adapt to the changes ahead.
We expect that the work of the current ad hoc committee, which is presently scheduled to conclude in Spring 2026, will be an important first step toward addressing the implications of AI for MIT education, but we note the importance of continuing to revisit these issues over the next several years. Specifically, we note that the response to AI in communications-intensive classes is an ongoing area of study for SOCR, and we recommend that SOCR be involved in any ongoing discussions.

Experimenting with Increased Curricular Flexibility

Throughout our process, TFUAP felt limited in its design options by a lack of data on the effects of providing more curricular flexibility. TFUAP has noted substantial interest from various members of the institute to decrease requirements and add flexibility. Proposals to add flexibility resulted in arguments from some community members that this would 1) decrease MIT's 'rigor', 2) lead to problems with students getting locked out of majors, and 3) cause students to go right into their major without exploring. We note that there is not substantial data for or against these arguments. We came to the conclusion that it is important for MIT to obtain data on what students do when provided with more flexibility to inform the next task force or group charged with examining the undergraduate program.

To explore this possibility, we recommend that the CUP consider designing and authorizing a limited experiment that would allow up to 100 students per year to opt out of a small number of requirements. The goal of this experiment would be to learn what would happen if the GIRs were cut roughly in half. Note that the full design of the experiment and the decision of whether to run one or not is beyond the scope of TFUAP and this report; it should be considered by the CUP. Note, as well, that down the line, ideas for different experiments may come up and inform the work of a future committee like ours. A more general point is that MIT would be well served by a culture of tinkering, experimenting, and learning for its teaching practices, which we manifest in so many other areas.

As one concrete example, the experiment on flexibility could be structured as follows.

1. Newly admitted students would apply to join the experiment, and up to about 100 would be randomly drawn from applicants, with strata determined to be representative of the overall student body in terms of demographics and intended fields of study. The experiment would be available for three consecutive classes.
2. Students in the experimental group would:
    a. Complete any 36 units of the SMC GIRs
    b. Complete any 4 of the 8 HASS GIRs
    c. Complete all other requirements as outlined above
    d. Complete 1 fewer restricted elective in their major (note: this may not apply to ABET-accredited majors)
3. A study team would assess the impacts by comparing the experimental group to a control group of students who applied but were not accepted into the experiment.
    a. Measures would include tracking which GIRs students take, which courses they major in, their grades, and performance measures like fifth-week flags and CAP actions.
    b. Additional outcomes tracked would include participation in UROPs and other experiential learning, application and admission to graduate school, and first jobs after graduation.
    c. Outcome data would be supplemented by surveys of students in the experiment

and control groups.

4. After 7 years (allowing most members of the three experimental cohorts to graduate), the study team would report on the outcomes to the CUP and Faculty. The CUP would recommend next steps, which may include broader implementation of flexibility, affirmation of existing approaches, and further experiments with even more flexibility.

7: Conclusion

After more than two years of listening, learning, and discussing what it does and should mean to get an undergraduate education at MIT, we believe that we have proposed a curriculum and set of policies, programs, and committees that will serve our students well. In everything we proposed, we prioritized the qualities of challenge, collaboration, and creativity that have long characterized an MIT education while recognizing that students and faculty alike have a finite amount of time and energy to dedicate to their many worthwhile academic pursuits. This is not a new goal, and we hope that future faculty and administrators will continue to recalibrate to meet changing student needs.

On the whole, we are optimistic about the work ahead. The policies we proposed would ease stress and create opportunities for deeper engagement in residential learning. The governance structures would enable more agility, ongoing iteration, and collaboration to ensure that the undergraduate program remains current. And the curriculum we proposed would create more well-rounded students with a broader disciplinary toolkit to draw upon and a more nuanced understanding of the world around them. Implementing this new vision for undergraduate education will be challenging and will draw on the expertise of faculty, staff, and students from across campus. But if there is one thing we know about the MIT community, it is that we are not afraid of a challenge.

Appendices

A. TFUAP Charge and Membership
B. TFUAP Goals
C. Implementation Timeline
D. Supporting Data Regarding Scheduling Policies
E. References and Supporting Materials for Pedagogy Section
F. Analysis of Possible Impacts on Existing Major Requirements
G. Draft Syllabus for Revised 18.02
H. Information, Entropy, and the Quantum World (Possible 8.024) Outline and Notes

Appendix A: TFUAP Charge and Membership

Charge

As issued in January 2024

This Task Force responds to two different but overlapping needs:

- First, the need for a comprehensive regular review of our undergraduate educational program; this need was well articulated seventeen years ago by the Task Force on the Educational Commons (2006).
- Second, the need to educate future generations of leaders, problem solvers, and citizens so that they are prepared and enabled to invent a future that will enhance human life and the life of the planet.

The Task Force will consider all aspects of the undergraduate academic program as areas for potential improvement and revision. Its mandate extends to both curriculum and pedagogy and will encompass both the SME and HASS General Institute Requirements[11] (GIRs) as well as experiential learning. (Areas such as advising and the education of learners outside of MIT should not be considered to be within the scope of the Task Force). Any future vision or proposal will need to embody both changing needs and the enduring, core values that underlie our rigorous

[11] The principal aims of the General Institute Requirements might be stated as the provision of: (1) Foundational Building Blocks: The GIRs provide a common body of knowledge that faculty can then assume in teaching advanced subjects. (2) Literacy in Essential Fields: The GIRs provide substantive knowledge in areas with which every MIT graduate should have familiarity. (3) Methods for Creative Analytical Thinking: The GIRs teach modes of thinking and provide portable (transferable) tools, skills, and general strategies for formulating, analyzing, and solving problems. While these are the principal aims of the MIT General Institute Requirements, the specific subjects and experiences in the undergraduate program that may best achieve these aims have evolved over time. The background, interests, and expectations of our undergraduate students have changed in recent years, as have the fields they will enter, and both pedagogy and the technology available for delivering educational experiences have evolved in important ways.

educational programs. We will also look to this Task Force and the process of review for lessons that will help us to create an effective template for future educational review and adaptation, including parameters for educational experiments that will enable us to innovate and advance as part of an ongoing change process.

Preparatory work for this review will be undertaken by several Foundational Working Groups that have been charged to report on aspects of the current degree requirements, aspects of current educational policy, and a few additional areas of learning or investigation.[12] Informed by these reports, the Task Force should also conduct broad outreach to the MIT community to understand the challenges and opportunities for our residential program and to engage the community in this project.

Through its engagement with the MIT community, the Task Force will seek to understand the kinds of preparation our graduates need. Beyond MIT, the Task Force should also consider how our students are being prepared in K-12 education, investigate curricula, requirements, and structures at peer or similar institutions, and incorporate the findings of relevant external studies.

While the Task Force may arrive at its own recommendations and vision, one aspect of its work should be to solicit and evaluate short proposals by individuals or groups within the MIT community, whether for limited or more sweeping changes. The Task Force may wish to request further development of especially promising proposals or to confer with their authors.

Any vision, in order to be implemented, requires consensus. The consensus of the faculty may extend to a modest revision of our educational programs, or it may extend to something more expansive; we would encourage the Task Force to consider both what is achievable and what is imaginable and to engage in ongoing dialogue with the faculty and the broader MIT community as potential recommendations take shape. While a compelling unified vision may emerge, the Task Force may also wish to provide a choice of pathways or a multi-part, phased proposal. The Task Force should also consider mechanisms that would enable limited educational experiments and innovations for assessment and, potentially, broader adoption as appropriate.

Proposals by the Task Force for changes in the undergraduate requirements will be considered by the appropriate committees of Faculty Governance for their consideration; to expedite the process, we recommend regular interaction between the Task Force and both CUP and FPC as these proposals are being drafted. The Task Force report may include proposals for motions to

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[12] Three of the Foundational Working Groups will focus respectively on the current state of the SME (science-math-engineering) and HASS (humanities-arts-social sciences) components of the GIRs and the Communication Requirement; these reports will be prepared by the committees charged with overseeing these three requirements. Further foundational work will be provided through three recent reports reviewed and updated as necessary for the purposes of the Task Force: the reports on Computational Thinking, Social Equity and Civic Responsibility (RIC2), and Lessons from Online Learning. Finally, the Committee on the Undergraduate Program has been asked to prepare a report on policies that shape the current undergraduate program.

amend the Rules and Regulations of the Faculty if needed for implementation of its recommendations.

Committee Membership

Adam Martin, Co-Chair; Salvador E. Luria Professor, Department of Biology
Joel Voldman, Co-Chair; William R. Brody (1965) Professor, Department of Electrical Engineering and Computer Science
Esther Duflo, Abdul Latif Jameel Professor of Poverty Alleviation and Development Economics
Jeffrey Grossman, Morton and Claire Goulder and Family Professor in Environmental Systems, Department of Materials Science
Isaac Lock ’25, Course 20 and Course 24-1
Robert Miller, Distinguished Professor in Electrical Engineering and Computer Science
William Minicozzi, Singer Professor, Department of Mathematics; Chair, Committee on the Undergraduate Program
Caitlin Ogoe ’25, Course 6-9
Janet Rankin, Director, Teaching and Learning Lab
Skylar Tibbits, Morningside Academy for Design Professor, Department of Architecture
Lily Tsai, Ford Professor, Department of Political Science
Maria Yang, William E. Leonhard (1940) Professor of Mechanical Engineering
Karen Zheng, George M. Bunker Professor of Management
Kate Weishaar, Staff, Division of Graduate and Undergraduate Education

Appendix B: TFUAP Goals

For a full explanation of these goals and how they were developed, please see the TFUAP Phase 1 Report.

Learning Goals

1. Every MIT graduate will know strategies for managing their time, advocating for and taking care of themselves, and finding fulfillment and belonging in their academic/professional pursuits and personal life.

2. Every MIT graduate will be equipped to define and solve problems using fundamental technical ways of thinking, including mathematical, computational, and scientific. Every MIT graduate will share a common base of technical understanding.

3. Every MIT graduate will be able to critically analyze their values and their responsibility to other people and the planet, and articulate reasons for their choices. They will understand relationships between individuals and society. Graduates will also know how to gather evidence from, interpret, and make arguments about events, texts, and artistic production from the past and present.

4. Every MIT graduate will be able to work collaboratively in teams, give and receive productive feedback, and take on leadership roles.

5. Every MIT graduate will be able to effectively develop and revise written, oral, and visual communication to articulate their ideas, claims, and arguments to a range of audiences. They will be able to actively listen to and engage with others whose perspectives differ from their own.

6. Every MIT graduate will be a critical reader, thinker, and listener who carefully examines assumptions, data, information, and ideas before formulating an opinion or proposing a solution.

7. Every MIT graduate will have the knowledge and skills to become a leading member and help advance the state of the art in their chosen field of study.

8. Every MIT graduate will be able to apply their knowledge and skills to solve real-world challenges. They will be able to ask insightful questions and have the flexibility to creatively address problems from a variety of contexts, even those different from their chosen field of study.

9. Every MIT graduate will be a curious, life-long learner, able to learn effectively in academic and non-academic contexts.

10. Every MIT graduate will be empowered to dream big. They will have the capacity to draw on their creativity to imagine, design, or build transformative future worlds that better serve humankind.

Process Goals

For all students, the MIT academic experience will:

1. Build & strengthen community, and support academic & social belonging
2. Support wellbeing
3. Include experiential learning and physical making/breaking
4. Celebrate unique passions, creativity, joy of learning, and sense of wonder
5. Provide meaningful mentoring relationships

Appendix C: Implementation Timeline

We provide a possible timeline for implementing the recommendations proposed in this report. As our ability to predict the future is limited, this timeline is intended to help guide but not dictate. Like all complicated projects, it will need to be revised over time.

Many of our recommendations ultimately require a vote of the MIT Faculty. This includes any changes to MIT's Rules and Regulations, including changes to GIRs, academic calendar, and registration. We are hopeful that these votes can occur in the 2026-27 academic year.

Curricular changes

Common Foundations. It will take 1-2 semesters to revise 18.02, which is the only subject with substantial initial revision in this list. Changes to the Physics GIR will be gradual and ongoing, though they may still require central MIT resources.

Flexible Foundations. The *ad-hoc* committees will take 12-18 months to be set up, develop their specifications, and work with departments and instructors to develop an initial set of subjects for the flexible foundations. Some subjects already exist (3.091, 5.11, 7.01x, etc.), but other subjects will need to be developed, including integrated offerings and some 6-unit offerings.

Teamwork-intensive Requirement. The *ad-hoc* committee will take 12-18 months to be set up, develop their specification, and work with departments and instructors to develop an initial set of subjects for this requirement.

CI Requirement. Changes to this requirement will take approximately 5 years, as described in detail in Section 2C.

Moral and Civic Perspectives Requirement. The *ad-hoc* committee will require 1-2 semesters to finalize the certification process and work with departments and instructors to develop an initial set of subjects for this requirement.

Experiential and Hands-on Learning. A working group would need 1-2 semesters to develop criteria for these designations.

Altogether, we anticipate that curricular changes can become effective for either the entering class of 2028 or 2029.

Policy changes

Clarity

Abolish the guidelines limiting overlaps between majors and GIRs. This can be incorporated immediately after a faculty vote.

Require that syllabi be posted publicly (or at least visible to all MIT users). This should be piloted with a subset of departments and then rolled out more broadly, taking 2-3 semesters.

Require interim grade reports one week before drop date. This should be piloted with a subset of departments and then rolled out more broadly, taking 2-3 semesters.

Commitment

Reduce scheduling conflicts and limit double-booking. This will take 3-4 academic years to fully implement and take effect. Full enforcement of a double-booking limit will require a new registration system to be in place, which is expected in the next several years.

Reset classroom expectations. This can be implemented the semester following discussion at an Institute Faculty Meeting.

Compassion

Add a class day on the current fall Registration Day and remove a class day on the Wednesday before Thanksgiving . This can be incorporated one or two academic years after a vote, depending on how far ahead the academic calendar must be finalized.

Prohibit instructors from setting assignment due dates on holidays, the day before or after Thanksgiving break, or the day after spring break. This can be incorporated the semester after a faculty vote.

Shift the "last test date" earlier in the spring semester to better align with the fall. This can be incorporated the semester after a faculty vote.

Changes to subjects and courses

We anticipate that many degree programs will make modest changes to their subjects and program structure in response to TFUAP's recommendations. Some departments may want to make changes immediately, and others may want to wait until particular curricular and policy changes are fully implemented. In either case, CoC will see an influx of minor or major changes to courses over 3-4 years. We strongly encourage the CoC to work proactively with departments so that changes can occur as quickly as possible.

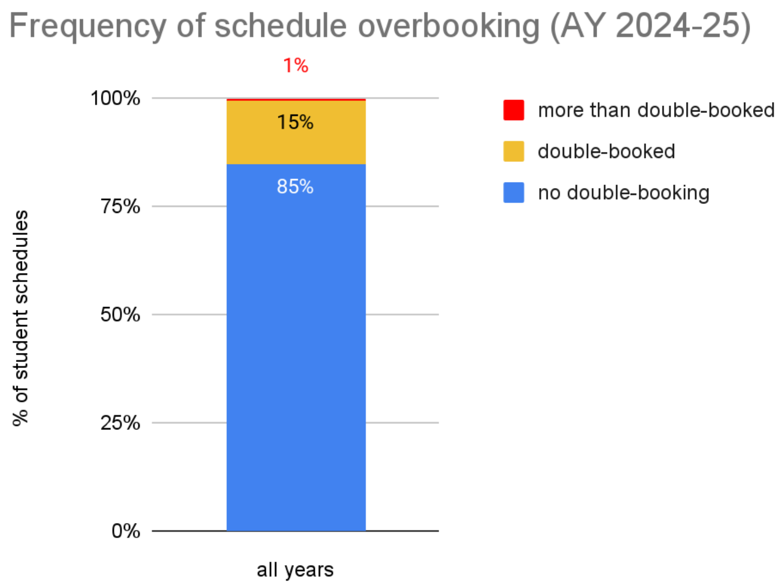
Pedagogy

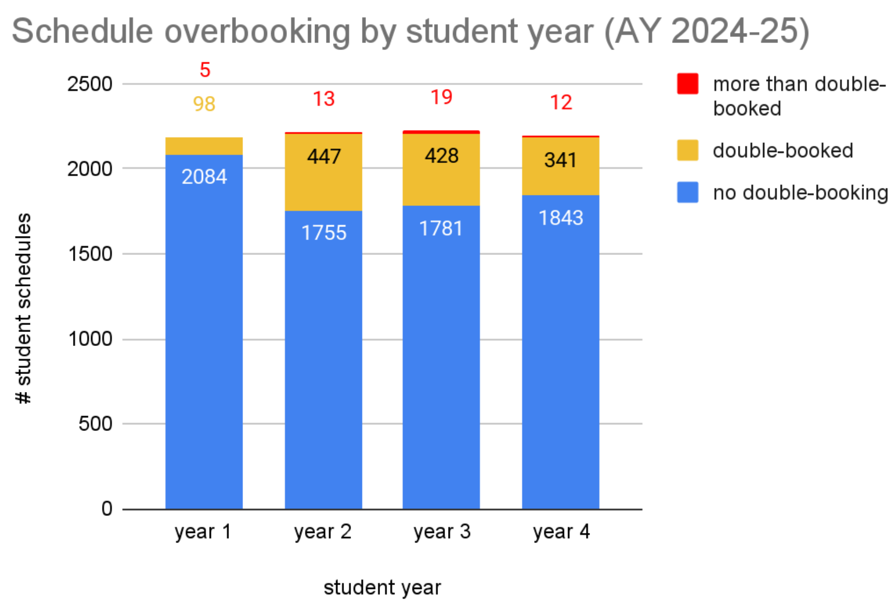
The sub-initiatives within pedagogy (CADI, SSTs, ISCoP) should be created alongside and with the same timeline as the commensurate curricular changes.

Flexible Curriculum Experiment

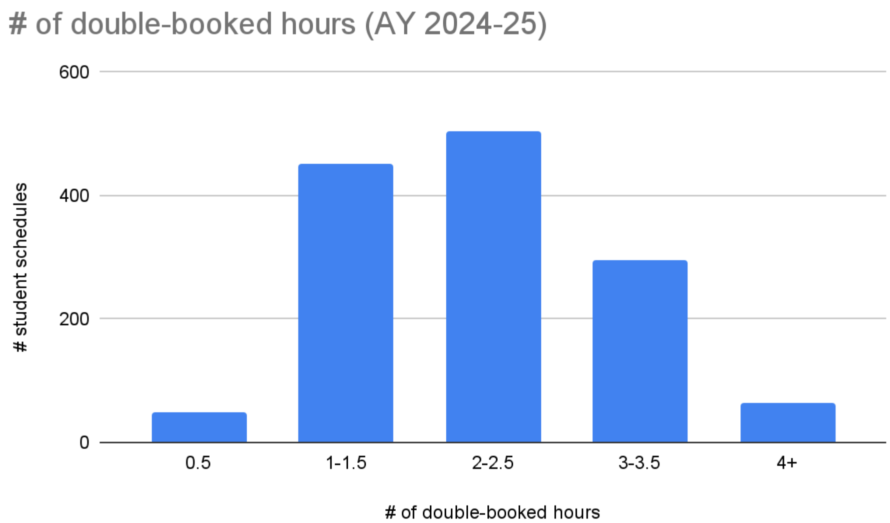
The timing of this experiment will be dictated by CUP.

Appendix D: Supporting Data Regarding Scheduling Policies

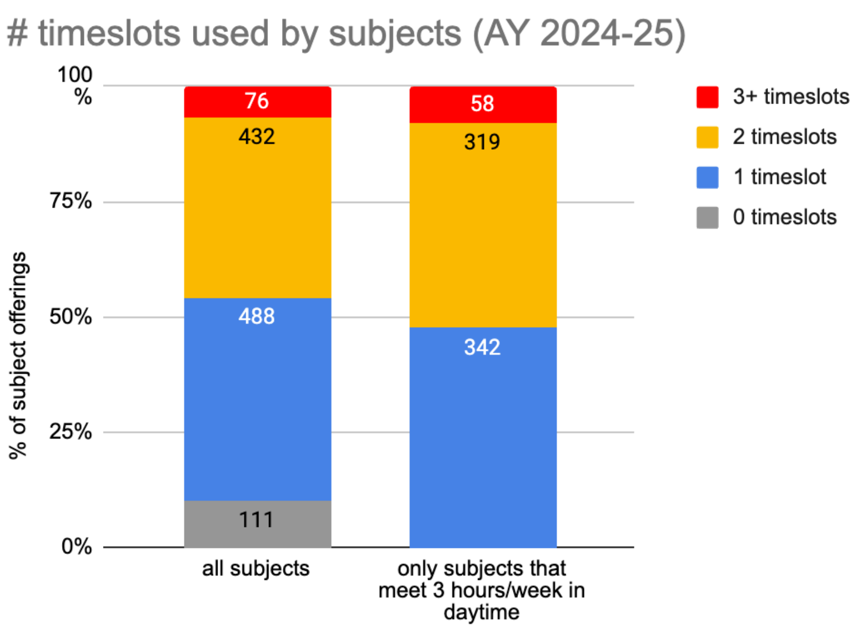


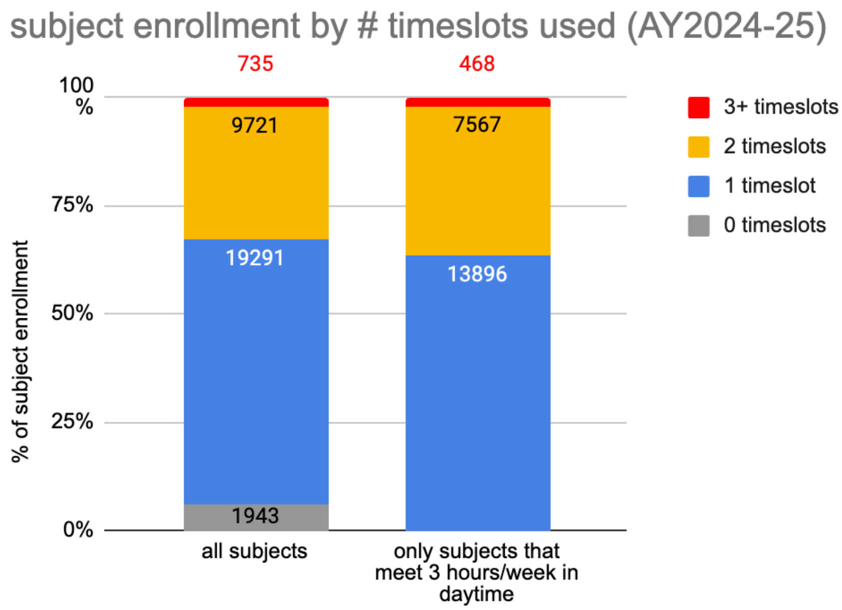


Frequency of overbooked schedules. "Double-booked" means that two of the subjects on the student's schedule have main lecture periods that overlap in time; "more than double-booked" means three or more subjects overlap. Data shows student schedules from fall 2024 and spring 2025, only undergraduate subjects with one lecture section where the student was registered for credit after Add Date. A typical student will have two schedules in this data, one for the fall semester and one for spring.



Number of hours double- or triple-booked. "Double-booked" means that at least two of the subjects on the student's schedule have main lecture periods that overlap in time. Data shows only double-booked student schedules from fall 2024 and spring 2025 (Course 6 majors or double-majors only). A student may have two schedules in this data, one for the fall semester and one for spring.





How timeslots are used by subjects. One "timeslot" in this analysis is one of the daytime meeting schedules recommended by the Registrar: MWF for one hour starting on the hour, or TR for 1.5 hours starting at 9:30, 11, 1, or 2:30. A subject uses 1 timeslot if its main lecture section fits entirely into one of those recommended meeting schedules; 2 timeslots if its lecture section overlaps two of those schedules. Evening subjects use 0 timeslots. Top graph shows number of offerings during the academic year (fall and spring count as separate offerings); bottom graph shows total enrollment in those offerings. The 2 and 3+ sections of the rightmost bars show that more than 50% of 3-hour-per-week lecture subjects are using nonstandard timeslots, overlapping more than one standard timeslot, and affecting 37% of the students enrolled in 3-hour-per-week lecture subjects.

Appendix E: References and Supporting Materials for Pedagogy Section

TFUAP White Papers Leveraged for this section

- Barnes: Optimizing the MIT Educational Experience Through Learning Science, Technology, and Collaboration
- Soicher: Pedagogical Professional Development for GIR Instructors
- Tomasik: A Community Approach to the Science-Core GIRs for Improved Coordination, Learning, and Assessment

Science of learning

- Applying the science of learning to the university and beyond: teaching for long-term retention and transfer D.F. Halpern, M.D. Hakel **2003** Change v35 no4 p36-42
- Deans for Impact (2015). *The Science of Learning*. Austin, TX: Deans for Impact
- Transfer as the goal of education, Authentic Education, Grant Wiggis, 2010
- Applying the Science of Learning/Research-Based Teaching Initiatives at other institutions
    - Cornell's Active Learning Initiative has transformed undergraduate courses by supporting
    - Purdue's leadership in Engineering Education has set a benchmark for integrating research-backed teaching to enhance the learning experience.
    - UMich Foundational Course Initiative

Interdisciplinarity

- Designing Interdisciplinary Courses William H. Newell defines interdisciplinary teaching as including 2 or more disciplines
- Defining and Teaching Interdisciplinary Studies William H. Newell and William J. Green, *Improving College and University Teaching*, Winter, 1982, Vol. 30, No. 1 (Winter, 1982), pp. 23-30. Published by: Taylor & Francis, Ltd. Stable URL: https://www.jstor.org/stable/27565474

  See the description of "Energy: A Combined Physical and Social Science Approach" on p. 27 (disciplines include chemistry, biology, economics, and political science):

  > *"...the Western [University] faculty have offered seminars in American Environmental History,the World Food Problem, Cubism and Relativity, Darwinian Influences on Nineteenth- and Twentieth Century Thought, and Creativity and Imagination in the Physical Sciences—all of which have required students to master technical subject matter in chemistry, physics, biology and geology."*

  See also the section on Educational Outcomes on p.29

- Interdisciplinary Curriculum Development William H. Newell *Issues in Integrative Studies*, No. 8, pp. 69-86 (1990). See, in particular, page 79, wherein Newell discusses the importance of early exposure to interdisciplinary ways of thinking:

  > *"Sequencing. Interdisciplinary courses represent a significant departure from the course structure and style of teaching and learning to which students are typically exposed in high school. They are most likely to accept the unfamiliar roles of faculty and students and the structure of an interdisciplinary course, and embrace its active, critically questioning style of learning, if they are exposed to it in the first semester of their first year in college, when studies indicate that the significant changes normally take place in college students. It is true that the relativistic thinking required in an interdisciplinary course may clash with the concrete thinking of some entering students [10], but interdisciplinary courses are an effective vehicle for moving students through Perry's stages (because they demonstrate the inadequacy of concrete thinking and the necessity of relativistic thinking and commitment), and the first semester of the first year is the time in college when they are most open to new thinking styles. Thus there are important advantages in introducing students to an interdisciplinary curriculum their first semester in college. Since interdisciplinary study builds directly on the disciplines while offering a holistic counterbalance to the reductionist perspectives they afford, a curriculum that intersperses disciplinary and interdisciplinary courses allows each to build on the strengths of the other, For example, after taking intermediate theory courses in economics, sociology, and political science, students might take interdisciplinary topical courses drawing on those analytical tools; e.g., an interdisciplinary course on modernization (replacing currently offered courses on political modernization, economic development, and the sociology of modernization). With the assistance of interdisciplinary courses, students can place in perspective the disciplinary tools they are acquiring, keeping sight of their limitations as well as their strengths, and assessing their relative contributions to complex issues.*
- Bio2010: Transforming Undergraduate Education for Future Research Biologists National Research Council (US) Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century. Washington (DC): National Academies Press (US); 200 (see examples & case studies in Section 3 - includes many examples (at various scales) from Bio + X courses.
- General Bio example: Tripp, B., Shortlidge, E.E. A Framework to Guide Undergraduate Education in Interdisciplinary Science. *CBE—Life Sciences Education*, Vol. 18, No. 2, 23 May 2019. https://doi.org/10.1187/cbe.18-11-0226 (Scroll down to sections: IDSF curricular Example and Implications for Core Competencies. The latter is particularly interesting because it highlights the ways that the interdisciplinary course can support the development of core competencies in Biology.)

Examples from MIT

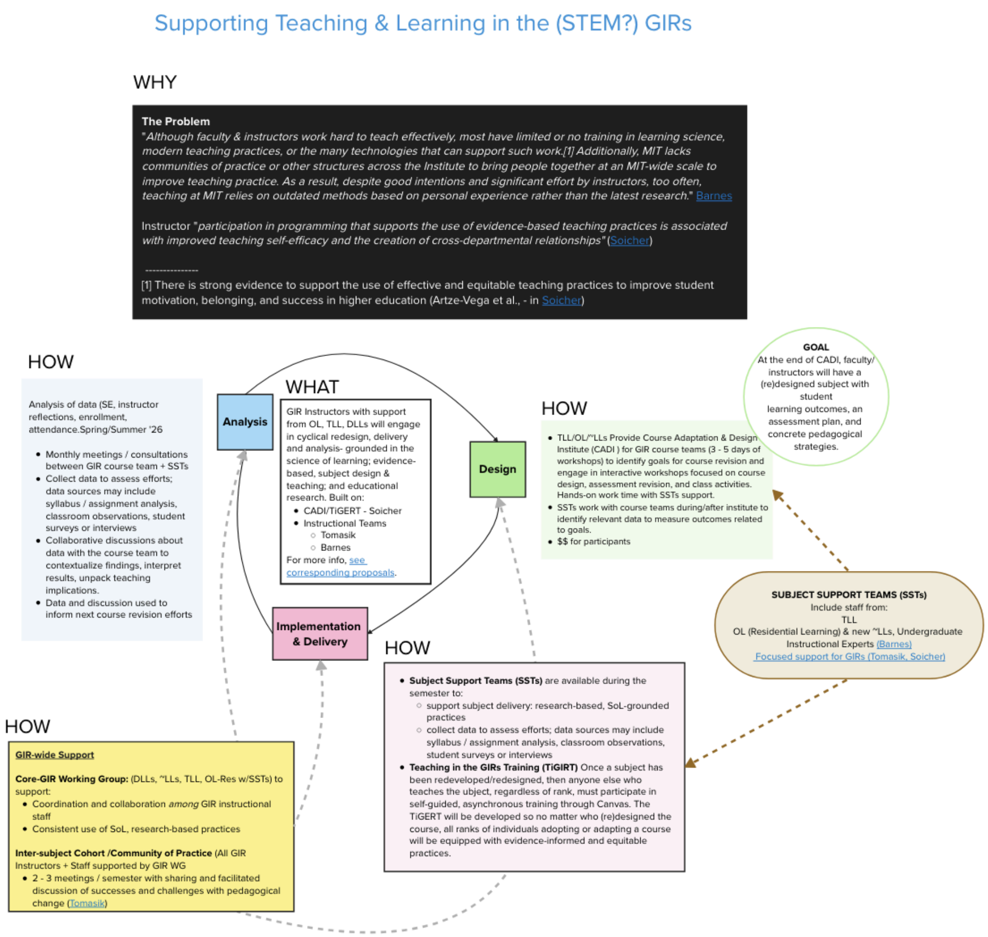
- 21.01 (Compass Course: Love, Death, and Taxes: How to Think — and Talk to Others — About Being Human)
- Vision in Art and Neuroscience (9.72) Pawan Sinha, Seth Riskin, Sarah Schwettmann

- Graham Jones & Seth Riskin [Paranormal Machines: Technologies of Enchantment in Science, Art, and Culture](#) (21A.S01)

Example from Other Institutions

- Duke: [BIOL 203 Molecular, Behavioral and Social Evolution: Evolution of Genomes, Traits, Behaviors, and Societies](#) (scroll down to the header: BIOL 203: An example)
- Dartmouth: Korey, J. (2002, July). [Successful interdisciplinary teaching: Making one plus one equal one](#). In *2nd International conference on the teaching of mathematics at the undergraduate level Hersonissos, Crete.*

Diagram illustrating connections between the proposed pedagogical programs



Click thumbnail for link to full framework

Appendix F: Analysis of Possible Impacts on Existing Major Requirements

TFUAP is proposing a wide set of changes, and a central question will be the impact on existing courses of study, many of which rely on existing GIRs and their structure. It is important to TFUAP that existing courses are strengthened by these recommendations, supporting learning goal 7. No major will be forced to decrease in size due to our recommendations. That said, the GIRs provide foundational knowledge for the majors, and as the GIRs change, the majors must also adapt; we have thus assumed modest "like-for-like" adaptation in our analysis below. The ultimate decisions will, of course, lie with departments, but we include the following analysis to explore possible approaches to reworking requirements in a subset of the majors that require the most units to complete and that rely on the SMC GIRs as prerequisites.

In our current system, majors have a maximum of 12.5 subjects and can specify up to 36 units of GIRs from the REST and Institute Lab subjects, allowing at most 15.5 subjects. In our recommendations, we propose to allow majors (courses) to increase from a maximum of 12.5 subjects to 14.5 subjects, reflecting in part the removal of the REST and Institute Lab requirements. We further recommend that majors be allowed to specify 12 units of GIR subjects (such as the Teamwork Intensive or Probability, Statistics, and Machine Learning subject), allowing up to 15.5 subjects for majors that do so.

Below we provide an analysis of selected majors, demonstrating approaches for all of them to fit within the revised guidelines, and sometimes even freeing up units.

SB in Engineering as recommended by Civil and Environmental Engineering (1-ENG)

- Current
    - 168 units in major, including 36 units via REST & Institute Lab
    - Requires 5.111/3.091 (for 3.010)
- Potential adjustment
    - Computing: New computing GIR would substitute for 1.000 [12 units removed]
    - Teamwork Intensive: 1.013 + 1.101 [existing, 12 units O/L]
    - Opportunities exist for adjusting 1.010A/1.073/1.074 to fit within the PSM requirement
- Net impact: (168) + (-12 changed) = 156 units (13 subjects, including 12 units overlap via TI subject)

Mechanical Engineering (2)

- Current
    - 177-180 units in major, including 36 units via REST & Institute Lab
    - Requires 8.01 (for 2.001), 8.02 (for 2.003, 2.004, 2.005), and 5.111/3.091 (for 2.002)
- Potential adjustment

    - Physics: the 2.00x series would build on the physics GIR and 8.02 [12 units added]
    - Computing: Either 2.086 certified/revised to meet computing GIR or revise course to use new computing GIR [12 units removed]
    - Integrated Chemistry/Biology: New GIR class substitutes for 5.111/3.091 or major requires 12 units of Chemistry [no units change]
    - Teamwork Intensive: 2.009, 2.013 2.750J, or 2.760 [existing, 12 units O/L]
- Net impact: (177-180) + 0 units = 177-180 units (14.75-15 subjects, including 12 units overlap via TI subject)

Materials Science and Engineering (3)

- Current
    - 168-174 units in major, including 36 units via REST & Institute Lab
    - Requires 5.111/3.091 (for 3.010)
- Potential adjustment
    - Computing: New computing GIR would substitute for 6.100A [6 units removed]
    - Integrated Chemistry/Biology: New GIR class substitutes for 5.111/3.091 or require full 5.111/3.091 [0-6 units added]
    - Teamwork Intensive: 3.042 [existing, 12 units O/L]
    - Opportunities exist for adjusting 18.03/18.06/18.C06 requirement and/or 3.029 requirement
- Net impact: (168-174) + (-6 to 0 changed) = 162-174 units (13.5-14.5 subjects including 12 units overlap via TI subject)

Electrical Engineering with Computing (6-5)

- Current
    - 174-186 units in major, including 36 units via REST & Institute Lab
    - Requires 8.02 (for 6.200)
- Potential adjustment
    - Physics: 6.200 would depend on 8.02 [12 units added]
    - Computing: 6.100 would substitute for 6.100A [6 units removed]
    - Linear Algebra removed due to inclusion in 18.02 [12 units removed]
    - Teamwork Intensive: 6.900 [existing, 12 units O/L]
- Net impact: (174-186) + (-6 changed) = 168-180 units (14-15 subjects including 12 units overlap via TI subject)

Chemical Engineering (10)

- Current
    - 174-183 units in major, including 36 units via REST + Institute Lab
    - Requires 8.01 (for 10.10), 7.01 (for 7.03), 3.091/5.111 (for 5.12 & 10.10)
- Potential adjustment
    - Physics: 10.10 builds on physics GIR [no units change]

    - Chemistry: Full 12-unit version required [no units change]
    - Teamwork Intensive: 10.26, 10.27, 10.28, 10.29, or 10.467 [existing, 12 units O/L]
- Net impact: 174-183 units = (14.5-15.25 subjects including 12 units O/L) [no change]

Chemical-Biological Engineering (10-B)

- Current
    - 180 units in major, including 36 units via REST + Institute Lab
    - Requires 8.01 (for 10.10), 7.01 (for 7.03), 3.091/5.111 (for 5.12 & 10.10)
- Potential adjustment
    - Physics: 10.10 builds on physics GIR [no units change]
    - Major would require 12 units of Chemistry and 12 units of Biology [no change]
    - Teamwork Intensive: 10.27, 10.28, or 10.29 [existing, 12 units O/L]
- Net impact: 180 units = (15 subjects including 12 units O/L) [no change]

Aerospace Engineering (16)

- Current
    - 180-186 units in major, including 36 units via REST + Institute Lab
    - Requires 8.01 (for 16.001), 8.02 (for 16.002, 16.003, 16.004)
- Potential adjustment
    - Physics: 16.00x series builds on physics GIR and 8.02 required [12 units added]
    - Computing: New computing GIR would substitute for 6.100A/(6.100B or 16.C20) requirement [12 units removed]
    - Teamwork Intensive: via one "Laboratory & Capstone" subject [existing, 12 units O/L]
- Net impact: (180-186) units (15-15.5 classes including 12 units O/L) [no change]

Biological Engineering (20)

- Current
    - 180-183 units in major, including 36 units via REST + Institute Lab
    - Requires 7.01 (for 7.03), 8.01/8.02 (for 20.110), 3.091/5.111 (for 5.12)
- Potential adjustment
    - Physics: 20.110 builds on physics GIR [no units change]
    - Computing: New 6-unit computing GIR would substitute for 6.100A requirement [6 units removed]
    - Major would require 12 units of Chemistry and 12 units of Biology [no change]
    - Teamwork Intensive: no existing class, but 20.309 could be adjusted [12 units overlap]
- Net impact: (180-183) units + (-6 units changed) = 174-177 units (14.5-14.75 classes including 12 units O/L)

Nuclear Science and Engineering (22)

- Current
    - 186 units in major, including 36 units via REST + Institute Lab and 12 units via HASS
    - Requires 8.02 (for 2.005)
- Potential adjustment
    - Physics: require 8.02 because 2.005 builds on it [12 units added]
    - Computing: New computing GIR would substitute for 6.1000 [12 units removed]
    - Teamwork Intensive: via 22.033 [existing, 12 units O/L]
    - Opportunities exist for Mathematics Elective to utilize PSM instead
- Net impact: (186) units + (0 units changed) = 186 units (15.5 classes including 12 units O/L + 12 units HASS)

Computer Science and Molecular Biology (6-7)

- Current
    - 180-186 units in major, including 36 units via REST + Institute Lab
    - Requires 7.01 (for 7.03), 3.091/5.111 (for 5.12)
- Potential adjustment
    - Computing: New 6-unit computing GIR would substitute for 6.100A requirement [6 units removed]
    - Major would require 12 units of Chemistry and 12 units of Biology [no change]
    - Probability, Statistics, and Machine Learning: 6.C01/7.C01 [12 units overlap]
- Net impact: (180-186 units) + (-6 units changed) = 174-180 units (14.5-15 classes, including 12 units overlap)

Physics (8)

- Current
    - 174 units in major, including 36 units via REST + Institute Lab
    - Requires 8.01&8.02 (for 8.03), 8.02 (for 8.033)
- Potential adjustment
    - Physics: New GIR class substitutes for 8.01, 8.02 still taken [12 units added]
    - Teamwork Intensive: no existing class, 8.13 or 8.14 could be adjusted to include teamwork [12 units overlap]
- Net impact: 174 units + (+12 units added) = 186 units (15.5 classes including 12 units overlap)

Chemistry and Biology (5-7)

- Current
    - 154-157 units in major, including 36 units via REST + Institute Lab
    - Requires 8.01 (for 7.03), 3.091/5.111 (for 5.12), 7.01 (for 7.03)
- Potential adjustment

    - Major would require 12 units of Chemistry and 12 units of Biology [no change]
- Net impact: (154-157) units = (12.8-13.1 classes) [no change]

DRAFT SYLLABUS FOR REVISED 18.02

Here is a possible syllabus for a revised version of 18.02 following the ideas presented in TFUAP. It would include some multivariable calculus and some linear algebra and try to include connections between them.

This draft was put together by faculty in mathematics and subsequently discussed by our departmental education committee. The next step is to discuss the topics with other departments at MIT to make sure that the choices serve their students well. We anticipate that the draft will evolve further during this process.

The main topic in the class would be multivariable functions, including functions from $\mathbb{R}^n$ to $\mathbb{R}^m$. Students would get used to functions on $\mathbb{R}^2$ and $\mathbb{R}^3$ and also functions in high dimensions. They would get used to functions to $\mathbb{R}$ but also functions to $\mathbb{R}^m$. A possible title for the class might be: Mathematics in multiple dimensions. Or Mathematics with multiple variables.

18.02 has about 33 lectures, not counting midterms and review classes.

The order of the topics below is not necessarily the order in the course. In particular, it might make sense to go back and forth between calculus concepts and linear algebra concepts.

Compared to the old 18.02, we removed 12 lectures on vector calculus and possibly some material on triple integrals, and we added 10–11 lectures on linear algebra beyond the 3 existing lectures on linear algebra, as well as a little more material on 2nd derivatives (using the linear algebra).

Items in blue are new topics being added to 18.02.

~~Items in red are old topics from 18.02 that would be removed.~~

1. Vector and matrix fundamentals [4 lectures, same as the old 18.02]

Functions with multivariable input and/or output, domain, codomain, range, notation such as $x_1, \ldots, x_n$ for functions of *many* variables

Vector addition. Scalar times vector.

Dot product. The component of a vector in a given direction.

Matrix addition. Matrix times vector. Matrix times matrix.

Matrices as linear transformations. Examples including rotation matrix, scaling matrix, projection matrix, reflection matrix. We will definitely cover such examples in two dimensions, and possibly some examples in higher dimensions.

2. Vector-valued functions of one variable [1 lecture, same as the old 18.02]

Derivatives and integrals of vector-valued functions

Parametrizing lines and curves

Velocity, arc length

Acceleration. Kepler's second law

3. Multivariable functions and their first derivatives [6 lectures, same as the old 18.02]

Depictions of a multivariable function: map of values, graph, level curve

Equations of planes

Partial derivative, total derivative (Jacobian matrix)

Linear approximation

Gradient descent

Newton's method in multivariable context (using linear approximation repeatedly to approximate the solution to an equation of the form $\mathbf{f}(\mathbf{x}) = \mathbf{a}$).

Maximum and minimum, least squares

Differentials, chain rule

Date: March 17, 2026.

Gradient, tangent plane, directional derivative

4. Linear algebra [13-14 lectures, compared to 3 lectures in the old 18.02]

Solving systems of linear equations. [3 lectures]
Gaussian elimination, row echelon form, behavior of solution set in homogeneous and inhomogeneous cases.

Determinants and inverse matrices. [2 lectures]
Determinant of a 2×2 matrix.
Connection between determinant and invertibility.
Geometric meaning of determinant.
Some discussion of determinant in higher dimensions.

Bases and independence. [3 Lectures]
Linear combinations, span, linear dependence, basis.
Connection between invertibility and these topics.
Coordinates with respect to a basis, changing coordinates
Orthogonal basis, orthonormal basis

Spaces associated to a matrix. [2–3 lectures]
Null space, column space, rank, rank-nullity theorem

Eigenvalues and eigenvectors and diagonalization. [3 Lectures]
Finding eigenvalues/eigenvectors of a 2×2 matrix using determinants.
Application to raising a matrix to a high power.
Eigenvalues and eigenvectors of symmetric matrices in n dimensions.
Distinction between the symmetric case and general case. (In symmetric case, eigenvalues are real and eigenvectors form an orthogonal basis. In the general case, eigenvalues can be complex, and eigenvectors may not form a basis.)

5. Multivariable functions and their second derivatives [2–3 lectures, compared to 1 lecture in the old 18.02]

Second partial derivatives. Second derivatives commute.
Hessian matrix.
Degree 2 Taylor polynomials in two or more variables (after review of one variable)
Accuracy of linear approximation.
Eigenvalues of Hessian matrix and minima/maxima/saddle points.
Convexity: definition, checking convexity, understanding the level curves of a convex function.

6. Complex numbers [1 lecture]

Complex arithmetic
Norm and argument of complex numbers. How these behave when we multiply complex numbers.
$e^{i\theta}$, complex exponential function

7. Integrals of multivariable functions [4–5 lectures, compared to 5 lectures in the old 18.02]

Double integrals in rectangular and polar coordinates
Applications such as mass, centroid, moment of inertia, volume of revolution, expected value
Change of variables in double integrals
If time: Triple integrals in rectangular, cylindrical, and spherical coordinates.
(Students have difficulty working with 3-dimensional regions, and this is worth practicing if we have time for it.)

8. ~~Vector calculus~~

We used to spend about 12 lectures on vector calculus, which would be removed from 18.02 in this plan.
~~Vector fields, line integrals, fundamental theorem of calculus for line integrals~~
~~Divergence and curl~~
~~Conservative vector fields~~
~~Parametrized surfaces~~
~~Surface integrals, flux~~
~~Divergence theorem, Stokes' theorem (with Green's theorem and Green's theorem for flux as 2D versions)~~
~~Maxwell's equations~~

Appendix A. Downstream effects

- The vector calculus content could be moved to a supplemental class taught during fall and/or IAP, or merged with a physics class such as 8.02 that uses this material to see it in context.
- 18.03 would require 18.02 as prerequisite (currently 18.02 is only a corequisite), and would need a major revision given that students would be coming in with so much linear algebra.
- 18.06/18.C06 would need a major revision.

INFORMATION, ENTROPY & THE QUANTUM WORLD

8.024(?) — SPRING 202X

OUTLINE & NOTES — May 2026

This document is an outline of, and notes regarding, a possible 12 unit Physics GIR subject for any MIT undergraduate who has credit for 8.01 and 18.01 from high school or has taken 8.01 and 18.01 at MIT. For concreteness, we will refer to this new subject as 8.024. Its working title is "Information, Entropy, and the Quantum World." This subject relies directly upon concepts and problem-solving skills learned in 8.01. After completing 8.01, future students could choose either 8.02 (Electricity & Magnetism) or 8.024. We also anticipate that 18.02 (as redefined following the TFUAP recommendations) would be a co-requisite for 8.024, as that would allow the second half of 8.024 to take advantage of linear algebra taught in the first half of the new 18.02.

The first half of this outline is the outline of 8.S014 "Information & Entropy; Energy & Exergy" (IE^3) — as taught in IAP 2025. 8.S014 was developed by Bob Jaffe, Michelle Tomasik and Krishna Rajagopal and taught by Krishna Rajagopal. As taught in IAP, it was 15 classes, and the outline below still reflects that. We would trim it to 13 classes when we repurpose this as the first half of 8.024. This will be easy to do, but has not been done in the outline below. Much work remains to be done in building the first half of 8.024 upon what we taught as 8.S014, including developing demonstrations and experiments, developing many more in-class materials including more group problems, and many more problems for problem sets and exams.

The second half of this outline was developed by a working group chaired by Krishna Rajagopal, charged by Physics Associate Department Head Scott Hughes, and including Kevin Burdge, Joe Checkelsky, Joe Formaggio, Aram Harrow, Bob Jaffe, Yen-Jie Lee, Michelle Tomasik as well as Scott and Krishna, that spent January 2026 brainstorming how to (re)design first-year physics courses that meet the needs of the MIT community if, as TFUAP is proposing, it becomes possible for us to offer two different second-Physics-GIR subjects with differing content but the same higher-level goals, with majors having the option to specify which they require.

In February 2026, we provided four recommendations and a report to the Physics Department. One of those recommendations was that the Department form a team that starts from the brainstorming that we did in January 2026, pivots to course development, and begins to create materials for 8.024. The Department accepted that recommendation and Aram Harrow, Krishna Rajagopal, Byron Drury and Michelle Tomasik have begun this work and hope to offer an IAP2027 pilot that would field-test ideas for the second half of 8.024, just as the IAP2025 offering of 8.S014 did for the first half. Another recommendation noted that we had begun consulting with faculty from other departments in January 2026 but recommended that Scott and Krishna have many more conversations with interested faculty from other departments; they have been reaching out to colleagues. We hope that sharing this outline broadly will prompt interested colleagues to reach out to Krishna or Scott.

In the longer term, if the full 12 unit 8.024 is developed and piloted successfully and becomes a regular offering to MIT's broad undergraduate community, and if MIT decides to go in the direction that TFUAP recommends, we anticipate that the future GIR requirement for all MIT undergraduates will be that those students who arrive at MIT with credit for 8.01 will be required to take either 8.02 or 8.024. Everything in both will be tied directly to fundamental laws and foundational aspects of how we understand the physical world from first principles. Either or both will elevate the problem-solving abilities and critical thinking skills of a student coming from 8.01, while introducing notions (electric and magnetic fields and Maxwell's equations in 8.02; bits, information, entropy, exergy, qubits, superposition and entanglement in 8.024) that are more abstract than the notions from 8.01. Either or both will connect the fundamentals rigorously to natural phenomena and to technologies.

We also anticipate that some majors will require that their students (whether they took 8.01 at MIT or arrived at MIT with 8.01 credit) take 8.02, some majors will require that their students take 8.024, and some majors will require that their students take both 8.02 and 8.024.

The second half of this outline/notes is not as developed as the first half, as it is based only on the January 2026 brainstorming. Also, it includes more topics (probably again by 15% or so) than will ultimately be included in 8.024.

This preamble is dated May 10th, 2026, and was prepared by Krishna Rajagopal. The notes below are from the January 2026 brainstorming by the working group members named above.

Section I: Information and Entropy; Energy and Exergy; Qubits and the Quantum World

Class 1 (Counting of classes refers to MW classes, and does not include FPS on Fridays. So, two classes per week.) Learning Sequence 1 (LS1).

A brief introduction to 8.024; motivations for the course.

The first half of 8.024 will revolve around four words: information, entropy, energy and exergy. Only one of these words is familiar from 8.01; by Spring Break we'll see how each of the other three fits in, and is just as crucial to understanding the world around us and our technologies as energy is.

As of Spring Break, one of the major gaps in your post-8.01 understanding of the physical world will have been filled in, but an even bigger gap remains. After Spring Break, we introduce quantum bits, qubits, and see how quantum mechanics transforms our understanding of information and the physical world.

In this first class, I will frame four questions that will animate our entire semester. By Spring Break, you will understand the answers to, and implications of, the first two of these questions completely, and from many perspectives. We will introduce qubits and the quantum world after Spring Break, and by the end of the semester you will understand the third and fourth questions which cannot be answered without quantum mechanics.

- Why is it so hard to pull CO_2 out of the atmosphere, when it is easy to dump CO_2 into the atmosphere? Both are equally allowed by energy and momentum conservation and everything we know from 8.01. This is a great example of how the physics of 10^{23} particles is different in fundamental ways from the physics of 2 or few particles – "More is Different". Building up the foundations of understanding that we need to answer this question from first principles will take us on a three-week journey through probability, information theory, irreversibility, entropy, and the second law of thermodynamics.
- What do we mean by "consumption of energy", "saving energy", "producing energy", or "we have an energy problem" given that we learned in 8.01 that energy is conserved?

Energy *is* conserved. Always. What we actually mean when we say things like this has everything to do with exergy – which is a measure of the quality of an energy resource. Exergy can be wasted/consumed, or saved, or produced. And, consuming exergy always involves producing entropy, so we will need to have understood entropy thoroughly, backwards and forwards, before we introduce exergy in week 4. It is exergy we need to power modern society. And, we have an exergy problem, not an energy problem.

- The first half of the semester began with information theory — which is all about bits. All of computation can be understood as the manipulation of bits. Or can it? What is different about a *quantum mechanical* two-state system, or qubit? What experiments force us to consider superposition? Entanglement? What is quantum mechanics? This opens the door to quantum communication and cryptography, quantum computing. We will end the semester with a rigorous understanding of simple examples of what qubits can do that bits cannot, and the foundations for understanding much more.
- In the first half of the semester, along with understanding entropy you'll understand temperature. Or will you? From what you will learn in the first half of a semester, you would conclude that when you heat a pot of water from room temperature to 100°C, a lot of the energy you add to the water should go into exciting the electrons in every atom and exciting the quarks in every proton. Is this really true? Answer, NO! What are we missing? The quantization of energy. Given what you learned in the first half of the semester, you will see by the end of the semester that many of the most basic features of the world around us (including for example that it doesn't take an infinite amount of energy to boil a pot of water) can only be understood in the quantum world.

Section II: Foundational Ideas and Terminology

Class 2. LS2

- Avogadro's number, and some intuition for *very* large numbers like this.
- A brief introduction to probability, via the flipping of (many) coins. Coins as two-state systems, or *bits*.
- Stirling Approximation.
- Macrostates and Microstates.
- Extensive variables and intensive variables.
- Internal energy and thermal energy.
- Heat flow; temperature and entropy (vague here, defined in Sections III and IV)

Section III: Entropy and the Second Law, Microscopically

Classes 3 and 4. LS3 and LS4. *Sections III and V from IE^3 can be combined into a single three-class section, after first introducing information theory. That is, this material would come after what is here Section IV.*

We will start from a microscopic perspective, with Boltzmann's definition of entropy. Much (although not all) of the essence of what entropy is, and of the second law, is captured beautifully by a simple microscopic model that I learned from P.W. Atkins' book "The Second Law". This Section will be an extended riff on this example.

- Equilibration and irreversibility as seen by a macroscopic "thermodynamic observer", even when microscopic laws are reversible.
- The lack of rules and the vastness of the space of possible microstates accounts for the irreversibility of equilibration.
- Hot objects cool to room temperature; room temperature objects don't warm up spontaneously. Cold objects warm up to room temperature; room temperature objects don't cool spontaneously. "Don't" means very unlikely, so improbable as to be impossible.
- Introduce Boltzmann's definition of entropy. Review the above through this lens.
- Fundamental definition of temperature.
- Entropy measures the vastness of our lack of knowledge: how many bits of information it takes to specify a microstate given what we know macroscopically?

Section IV: From Information to Entropy

Classes 5 and 6. LS5 and half of LS6.

In 1948, Claude Shannon (who was later an MIT professor for many years) put our understanding of entropy on a much firmer foundation. He came to this via first reinventing and naming "information theory", and introducing "information entropy".

- Information entropy is the minimum number of bits required, on average, to encode a sequence of letters or numbers or other symbols.
- Shannon's Source Coding Theorem. Shannon defined the information entropy σ and proved that no encoding can be found that uses fewer than σ bits per symbol.
- Shannon's σ is related to Boltzmann's entropy S. Microstates in physics as symbols in information theory..
- Entropy is extensive.
- Thermal equilibrium, and the fundamental definition of temperature.
- Second Law of Thermodynamics.
- Second Law and asymmetry in time.
- Free expansion of a gas.

Section V: The Second Law, Macroscopically: Work, Engines, and the Fundamental Limit to Efficiency

Classes 7 and 8. LS6, LS7 and LS8.

The person who first understood (a version of) what we now call the Second Law, and in so doing elucidated nature's dissymmetry, was Sadi Carnot, long before Boltzmann. Carnot's ambitions were grand: he was attacking the big technological problem of his age. His *technologically motivated* studies would launch an intellectual revolution. More than 50 years later, Boltzmann understood the microscopic explanation of heat, thermal energy, temperature, and entropy. Carnot was a remarkable engineer; Boltzmann was a remarkable scientist – he came to these discoveries by attaching the *fundamental science* problem of his age. More than 50 years later again, Claude Shannon understood the connection between entropy and information, by quantifying information for the first time. His motivations were *computational*, technological, practical – wrestling with the big technological questions of his age. He, too, launched an intellectual revolution whose ramifications continue to spread today.

In this Section, we go back to Carnot's discovery, with the tools of Boltzmann and Shannon available to us.

- Second Law, à la Carnot.
- Energy is conserved, but its distribution changes irreversibly – as entropy increases.
- This dissymmetry does not exist in the laws of Newton, Maxwell or Schrödinger. It is fundamental to understanding nature and technology.
- Carnot understood this via the Carnot Engine and Carnot Cycle.
- Introduce work; define what we mean by an engine, and the efficiency of an engine.
- Internal energy, enthalpy, and heat capacities.
- Carnot Engine, described in the $P - V$ plane. Efficiency cannot be 100%.
- Second Law, Kelvin's version. Second Law, Clausius' version.
- Entropy and the Second Law, macroscopically speaking.
- Revisit Carnot Engine, in the $T - S$ plane.
- Carnot's discovery: a fundamental ceiling to efficiency.
- *Ely Sachs has an excellent Guided Discovery that could be turned into an in-class experiment*
- *IE^3 had a pair of problems that introduced the Stirling Engine. Pair this with an in-class experiment with a small Stirling Engine.*

Section VI: Entropy of an Ideal Gas

Classes 9 and 10. LS9 and LS10.

This Section is centered on an extended, explicit, and complete calculation of the entropy of a monoatomic ideal gas.

- Defining, and counting, the microstates. This involves doing a $6N$-dimensional integral, where N could be 10^{23}!!
- The result for the entropy of a monoatomic ideal gas; called the Sackur-Tetrode equation.
- Relation between thermal energy and temperature.
- From the Sackur-Tetrode entropy, *derive* the ideal gas law, $PV = Nk_B T = n\,RT$. At a fundamental level, the ideal gas law is built upon Boltzmann's definition of entropy which in turn is built upon Shannon's information theory.

- Information theory perspective on the entropy of a monoatomic ideal gas.
- Quantum mechanics can be neglected in this calculation as long as the temperature is "not too small". We shall see what the quantitative criterion is.
- An ideal gas of *molecules*. Relation between thermal energy and temperature changes. Ideal gas law does not.
- Compare and contrast three different ways via which one can double the volume of an ideal gas: adiabatic expansion, isothermal expansion, and sudden free expansion.

Section VII: Entropy of Mixing and CO_2 in the Atmosphere

Classes 11 and 12. LS11 and LS12.

We begin this Section with a classic application of what we learned in Section VI, a textbook problem: the Entropy of Mixing. We then apply this to *answer* the first of the two questions that we have used to motivate the entire course. Why is it not easy to removed CO_2 from the atmosphere?

- Entropy of mixing, when two (or more) gases mix.
- Separating a mixture into its components *decreases* the entropy. Which means it won't just happen.
- An unrealistic question: How much will the entropy of the earth's atmosphere be reduced if we remove *all* the CO_2 from the entire atmosphere? We answer this question first.
- What does the Second Law of Thermodynamics have to say? Doing the above will involve heating the atmosphere.
- A more realistic version of the mixing/unmixing calculation: we sequester N_0 molecules of CO_2; how much is the reduction in entropy? Second Law of Thermodynamics, again.
- If you want to remove CO_2 from the atmosphere and sequester it, called "Direct Air Capture", you will need to heat the atmosphere by at least the minimum required by the Second Law. Is this a lot of energy?
- Carbon Capture and Sequestration. Grab the CO_2 out of the chimney of a power plant, capture it, compress it, bury it. The key: grab it before it gets mixed into the atmosphere at large. Lets quantify why this is a better strategy than Direct Air Capture.
- *Some of the last parts of this can be turned into PSet problems. Also, add PSet problems on desalination of sea water, and on why erasing bits during a computation means heating the environment.*

Section VIII: Exergy and the Quality of Energy

Classes 13, 14 and 15. LS13, LS14 and LS15.

In this Section we will learn the fundamental physics principles behind any thinking you want to do about energy efficiency, energy conservation, and choosing between energy sources. None of these phrases make sense in literal terms, since as we learned in 8.01 energy is conserved. We need a notion of high quality energy, more useful energy, lower quality less useful energy. This requires introducing the notion of exergy.

- Exergy measures the capacity of a system to do useful work. Exergy is the maximum amount of useful work that can be provided by a material that serves as a "source of energy" as this material is brought into thermodynamic equilibrium with its environment. The exergy of a system depends on the state of the system itself and on the environment in which it finds itself.
- Review Carnot cycle and second law limit to the efficiency of an engine.
- Refrigerators and heat pumps, and their coefficients of performance.
- As a motivating example, we will compare and contrast three different ways of heating an apartment/house/dorm. (i) Use electricity from a power plant produced there by burning natural gas to run an electric space heater. (ii) Burn the natural gas in a furnace in your basement. (iii) Use electricity from the power plant to run an electric heat pump to heat your space.
- Define exergy.
- Actual useful work done as a system is brought from some initial state into equilibrium with its environment is equal to the exergy only if the total entropy does not increase.
- Anything that increases the total entropy reduces the useful work that a system can perform.
- Consumption of exergy $\leftrightarrow$ Production of entropy. Exergy can be consumed/wasted.
- Exergy can also be produced. Doing so takes work.
- What we colloquially refer to as "energy consumption" is actually exergy destruction. It is irreversibility that is responsible for destroying exergy.
- What we colloquially refer to as "energy efficiency" and "energy conservation" are actually about turning exergy into work with as little wasted as possible and about using as little exergy as possible. Exergy is the resource that humankind relies upon to power modern societies.
- Exergy of various sources/systems... Mechanical and electrical energy. Exergy of a compressed gas. Exergy of a hot object.
- The importance of large scale exergy storage, examples, and an exergy-analysis of Compressed Air Energy Storage.
- Comparison of different sources of exergy.

MIDPOINT: SPRING BREAK SHOULD LAND HERE

There are 13 classes before Spring Break. IE^3 was 15 classes. Combining Sections III and V would reduce by one. Will either need to reduce Section VIII from three classes to two, or tighten and trim throughout, or both.

Section IX: Why Qubits?

Class 14.

In quantum mechanics, many measurable quantities describing a physical system that are continuous variables in classical mechanics can only take on a discrete values. In a chemistry class in high school or at MIT you have heard of the Bohr atom: energy "levels" for the electrons in atoms. "Energy is quantized." We will come back to energy later. The simplest examples of quantization are two state systems like the spin of an electron. Isn't that just a bit?

Describe Stern-Gerlach experiment, somewhat like Allan Adams' first 8.04 lecture but showing pictures of the actual apparatus and deflection of atoms up or down, and left or right, depending on the spin of the electron. All with pictures.

Explain that it measures the z-component of the spin vector of an electron. S_z. Describe experiments (pictures) that show that this is quantized, with two possible states. Quite unlike classical expectation for a spinning sphere. Quantum in that sense.

But, so far, just like a bit!!

Describe measurement of S_x, and sequential measurements of S_z then S_x. OK, maybe the spin of an electron is like two bits??

Describe measurement of S_z, then S_x, then S_z. Cannot be understood in the language of bits, at all!

Qubits, and superposition. At this point a puzzle.

Section X: Superposition of Waves — and Particles

Class 15 and part of 16. Follows Cottrell Chapter 1. Also Schumacher & Westmoreland (S&W) Chapter 1 and first part of Chapter 2.

There is another context where superposition is not a puzzle at all. Superposition of waves. Young's two slit experiment. Not puzzling, just like water waves. *In class demos of two-slit experiment with water waves, and laser beam through a double slit..*

Light as photons. Descrbe two slit experiment, one photon at a time. Individual photons interfere with themselves. Probability amplitude.

Two path interferometer. When a photon is in a superposition of top path and bottom path, how do we describe it? $|+\rangle$ and $|-\rangle$. But also $|0\rangle$ and $|1\rangle$.

Complex numbers. Interference and phase. The state vector (for a two-state system).

Mach-Zehnder interferometer, possibly? Could do, but likely won't.

Make the analogy to the electron spin with which we began explicit.

Riff on lots of other examples. Polarization of light (measure in any direction). Spin of electron (measure in any direction). Electrons scattering off crystals $\leftrightarrow$ many-slit experiment.

In-class experiment with polarization of light, doing the analogue of measure S_z, then S_x, then S_z.

Section XI: Quantum States and Measurements

Part of Class 16, and Class 17. Cottrell Chapters 1 and 2. S&W Chapter 2.

Cottrell Sections 1.5-1.8 and 1.11: State vector. Bra-Ket notation. Inner product. Basis states. The probability of detecting $|\eta\rangle$ given that the state is $|\psi\rangle$ is $|\langle\eta|\psi\rangle|^2$. Global phase doesn't matter. What Cottrell calls the fundamental postulate.

Cottrell 2.1. Measurement as projection. Same state in different bases. Do this for electron spin example. but do an experiment in class with polarization of light so need that example too.

Polarizers in sequence — for light as a wave the results of sequential measurements of z then x then z polarization is not mysterious, because superposition of waves is not mysterious. Do this experiment.

What Cottrell calls the Measurement Postulate.

Return to electron spin example.

Reinforce difference between quantum state, and probability. Come back to this in Section XII.

Section XII: Operators and Eigenstates

Classes 18 and 19. Cottrell Chapter 3. S &W Chapter 3.

Operators, eigenstates, and eigenvalues. Cottrell 3.1-3.3. Skip 3.4.

Pauli Matrices. Cottrell 3.5

Evolution and Unitary Operators. Cottrell 3.6

Hermitian Operators. Cottrell 3.7

Compatible observables $\leftrightarrow$ Commuting operators

This section is a stripped down version of S &W Chapter 3, entirely for two-state system, not generalized as S & W do. Will strip this down as much as possible; decisions on what is the minimum we need to be made after Section XIV finalized. What is listed above seems too much, although Cottrell apparently does it in one lecture.

Further reinforce difference between quantum interference and classical probability by illustrating quantum interference vs classical addition of probabilities.

Section XIII: The Quantum World

Classes 20 and 21 and 22.

Start with S & W Chapter 2.3 Two-Level "Atoms". Two state system where the two states have different *energy*. Think of this as a toy-model-atom.

Time evolution. This is S & W Chapter 5, but we will do much less than is in this chapter, and only for two-state system.

Remind about the Bohr atom. If all you know is energy eigenstates — à la high school chemistry — *nothing happens.* Time evolution, *change*, requires superposition of energy eigenstates.

Statistical mechanics of two-state system, where the two states have different energies. Let's apply what we learned in the first half of 8.024: calculate the entropy of N two state systems. Information theory perspective on entropy. Relation between thermal energy and temperature in this context. Derive specific heat.

Statistical mechanics of N harmonic oscillators (in LS and class qualitatively, quantitatively on PSet)

The quantum ladder. Why you don't need to worry about exciting electrons in atoms or quarks in protons when you heat up a pot of water on your stove.

Section XIV: Quantum Communication and Cryptography, and the Uncertainty Principle

Classes 23 and 24 and 25. Cottrell Chapters 4 and 5. S & W Chapter 4.

Two qubits. Once two qubits have interacted, we usually need to think of them as a single, larger, quantum system. This is called entanglement. Will do this without introducing the full formalism of tensor product states. But will introduce 4×4 operators, including CNOT. This is all in Cottrell Chapter 4, but we will do only a fraction of this chapter. In S & W this is 6.1 and 6.2.

Bell states, and quantum teleportation. Cottrell 5.1-5.3

CHSH version of Bell inequality – entangled states cannot be used to signal instantaneously, but can result in correlations that are impossible classically. [

No-Cloning theorem. Cottrell 5.5. S & W 7.2

Quantum communication. S & W 4.1

Quantum cryptography and quantum key distribution. S & W 4.4, Cottrell 5.7

Uncertainty Relation S &W 4.5

Will make a selection from above. Each of the above is doable, but not all.

Section XV: Quantum Mechanics and Quantum Computing

Class 26.

End with a coda that looks ahead both to the quantum world and to the world of quantum computing.

A qualitative look ahead at a couple of examples from the quantum world at the research frontier — maybe entanglement of top quarks in LHC collisions, maybe a riff on superfluidity/superconductivity/quantum matter.

A qualitative look ahead at what computing with qubits can do that computing with bits cannot, with an example that has been achieved today and a look ahead. Can take some inspiration from Cottrell Chapter 6. Make the points he makes in 6.3 and 6.5. Reversible quantum computation cf entropy producing classical computation.

Won't teach Grover or Shor algorithms, but can report the speed-ups that superposition and entanglement make possible.