UNIVERSITY OF MICHIGAN
College of Engineering
Curriculum Committee Meeting
Tuesday, March 12, 2024

Attending: Achilleas Anastasopoulos, Robert Bordley, Yavuz Bozer, Robert Dick, Chris Fidkowski, Fei Gao, Saadet Guralp, Amir Kamil, Leena Lalwani, Xiaogan Liang, Emmanuelle Marquis, Frank Marsik, Radoslaw Michalowski, Yulin Pan, Mika Panagou, Eric Rutherford, Rachael Schmedlen, Jeffrey Scruggs, Ben Spector, Elyse Vigiletti, Roxanne Walker

Support Staff: Mercedes Carmona, Betsy Dodge, Matthew Faunce

Call to Order: 1:35 PM

Adjourned: 2:53 PM

Agenda:

1. Approval of 2.13.2024 Meeting Minutes – Page 4 – **APPROVED**
2. 3 CEE MSE Modification Program Proposals – Action Item – Page 7 - **APPROVED**
    a. All 3 Master of Science Degrees in Civil Engineering, Environmental Engineering, and Construction Engineering & Management from the Department of Civil & Environmental Engineering propose to reduce the credits from 30 to 26. The Rackham Graduate School currently imposes a 30-credit minimum requirement for all Engineering degrees, a restriction only put on the College of Engineering as other colleges/schools are allowed to be at a minimum of 24 credits. This requirement is handed down from the Michigan Association of State Universities (MASU) to be implemented by the Rackham Graduate School so CEE will need Rackham to grant this approval of reducing credits before presenting to MASU, as well as needing departmental, CoE Curriculum Committee, and CoE Faculty approvals in the process. The alterations of the MSE curricula for various specializations are minimal as Rackham use to require 3 credits of cognate courses to be taken outside of the department, which was eliminated in 2018, so students will still get the same level of technical preparation in CEE courses.
    b. This change helps in degree time reducing from 3 semesters to 2 therefore reducing total cost of tuition, improving the department's ability to leverage fellowship resources, and better marketing for Masters programs and in turn growing the Masters programs.
    c. Many departments commented on the Rackham Graduate School minimum credit requirement of 30 credits and the CEE department wanting to reduce to 26, as if approved, many other CoE programs will follow in reducing the credit minimum.
        i. The CLaSP department has a similar proposal to reduce minimum credits of 30 to 26, so is in full support and can assist CEE if support is needed.
        ii. ISD states that the Rackham Graduate School credit requirement is different between MS and MEng, which MEng is already at 26 credits.
        iii. EECS – ECE says that MEng was first introduced to overcome all the difficulties listed in the proposal and now to make MS closer to MEng, we need to convert to achieve the same requirements. How does this make sense?
            1. CEE Department says current requirements make it incredibly difficult to market CEE MS Programs. Why get an MS when you can get a MEng? More applicants choose MEng over MS due to the points listed, shorter time for a degree, less money, flexibility with classes, etc. Students who graduate with MEng were not to continue with the university as student may not realize they attend the same classes taught by the same professors. The CEE Department does not want to have to market 6 MS degrees.
                a. IOE agrees as there is a long and complicated history with MEng and MS degrees. MEng in Manufacturing was first introduced to the college, 25 years ago, and overtime all departments adapted this degree or an interpretation of it.
    d. Poll taken for CCC members to vote on the proposal and received a near unanimous vote for approval. This proposal will proceed to the next CoE Faculty Meeting and Jeff Scruggs to continue to present for the CEE Department.

3. CE BSE Modification Program Proposal – Action Item – Page 42 - **APPROVED**
    a. Currently, the CoE mathematics course requirements must be satisfied with Multivariable & Vector Calculus, MATH 215. The department proposal intends on permitting Linear Algebra, MATH 214, as an option to satisfy the math requirements of the Computer Engineering BSE program. Other course options listed in lieu of MATH 215 other than MATH 214 are MATH 217, MATH 417, or MATH 419. The CE Program is less flexible than other sister programs of Electrical Engineering and Computer Science, so this is preferred rather than adding another requirement.
        i. EECS – CSE comments that Computer Science has already done the same requirements for some time for the very same reasons stated.
    b. Poll taken for CCC members to vote on the proposal and received a near unanimous vote for approval. This proposal will proceed to the next CoE Faculty Meeting.
4. Questions for the CCC for Fall 2022 – Informational Item – Page 45
    a. The HLC Annual Audit cited EECS 587 as a 4 credit course that is not in alignment with the CoE Policy for the Assignment of Credit Hours, as the course is taught with 3 hours of Lecture and 1 hour of Lab. The department says there are 300 minutes of office hours in addition to the class and discussion section hours as well as significant use of Piazza so the students are interacting with GSIs and the professor more than 540 minutes per week. More time is spent on the computer and in class than other students in lab courses spend in the lab.
    b. Should the use of Piazza and office hours factor into contact hours? If so, how should these elements reflect in the CoE Policy for the Assignment of Credit Hours?
        i. Question raised by ChE as to how the office hours are scheduled, such as open for anyone to attend, like most office hours are set, or is this scheduled for each student to attend at a certain time to fulfill the 300 minutes.
            1. MECHENG/Chair states that if students are developing software and have real time interaction with the instructor, like a virtual lab, that this should count towards contact hours. But, if the student is just attending office hours to sit and complete homework, then this should not count towards contact hours. More details are needed to determine if this should or should not count towards contact hours.
        ii. BIOMEDE/ENGR/UG Edu. questions how the ratio of 2 hours of lab to 1 contact hour came about and sees that the spirit of contact hours is being met, but still sees the issue this raises.
        iii. ChE, EECS – CSE in agreement that this type of interaction should not count towards office hours. Additional course component, such as Recitation or Discussion, should be added to the course to comply with the credit hour policy.
5. CCC Review and Approval of Declaration/Common Requirements Changes – Informational Item – Page 46
    a. Kevin Pipe raised this issue to the CoE Registrar Office about what committee or group within the college can approve changes to Declaration and/or Common Requirements. The CoE RO found documents in previous CCC Meeting Minutes regarding this inquiry and are stated in the document.
    b. Vote was taken for both changes and both approved that the CCC should be the approving body for both Declaration and Common Requirements, which then proceeds to the Faculty Committee vote.
    c. Betsy will follow up with Kevin about the results and have this be a standing policy that all requirements will go through the CCC.
        i. The CCC Processes for Non-Course Related Requests document will be updated as a result.
6. HLC Annual Audit Questions 3 & 4 for the CoE Curriculum Committee – Informational Item – Page 47 – **PENDING**
    a. Review Draft HLC Discussion Document to finalize revisions to the current CoE Policy for the Assignment of Credit Hours.
        i. Xiaogan took edits from members into consideration and updated the draft policy to reflect feedback.
        ii. Change made to 'non-critical hardware' in the document as members gave feedback that this needed to be defined more.
    b. Members are to continue to make edits to the Draft HLC Discussion Document as needed. At the next CCC meeting, there will be a final review of the document and member vote for the revision of the current CoE Policy for the Assignment of Credit Hours.
7. CoE/LSA Joint Meeting Agenda Items – Informational Item - **PENDING**
    a. We are reaching out to ADUE and LSA to determine if a joint meeting is of interest between both colleges and determining what topics are to be discussed.
        i. Discuss CoE Incomplete Grade Policies and Course Withdrawals and the LSA I-Grade Policy.
        ii. The topics discussed thus far are not enough for a joint meeting to take place per chair.
    b. Any other topics that are urgent that would need for a joint meeting to take place?
        i. If there are any ideas or topics, please email Mercedes, carmonam@umich.edu, or Xiaogan, xiaoganl@umich.edu.
8. Tabled CARFs on today's agenda will be on the next CoE Curriculum Committee meeting agenda for 3.26.2024.

CARF SUMMARIES

PAGE	SUBJECT	COURSE #	ACTION	SUMMARY	EFFECTIVE TERM	MIN. GRADE REQ. FOR ENF. PREPREQ	Is Course on LSA Course Guide?	APPROVED	NOTES & REVISIONS	TABLED
50	CEE	212	MOD	Change in Advisory and Enforced Prerequisite.	WT 2025	C-	YES	APPROVED		
53	CEE	365	MOD	Change in Course Description, Enforced Prerequisite, and Course Components.	WT 2025	C-	YES	CONDITIONAL APPROVAL	Remove Advisory Prerequisites listed as these are requirements for the Enforced Prerequisite, CEE 265.	
56	CEE	450	MOD	Change in Course Description, Enforced Prerequisite, Course Components, and Contact Hours.	WT 2025	C	YES	CONDITIONAL APPROVAL	Define Enforced Prerequisites for "statistics classes". Need to list specific courses if you wish to be enforced.	
60	CEE	521	MOD	Change in Course Title, Advisory Prerequisite, and Course Components.	WT 2025	NO	YES	APPROVED		
63	CEE	537	MOD	Change in Course Credit Type, Advisory Prerequisite, and Terms Typically Offered.	WT 2025	NO	YES	APPROVED		
66	CEE	575	MOD	Change in Course and Abbreviated Titles and Course Description.	WT 2025	NO	YES	CONDITIONAL APPROVAL	Add spaces in the Abbreviated Title.	
69	CLIMATE	746	NEW		WT 2025	NO	NO	TABLED	Cross listed with SPACE 746.	
80	CSE	598	MOD	Change in Course Components.	WT 2025	NO	YES	TABLED		
83	ECE	510	NEW		WT 2025	NO	NO	TABLED	Cross listed with NERS 675	
93	ECE	598	MOD	Change in Course Components.	WT 2025	NO	YES	TABLED		
96	EECS	498	MOD	Change in Course Components.	WT 2025	NO	YES	TABLED		
99	ENGR	101	MOD	Change in Credit Exclusions.	WT 2025	NO	YES	TABLED		
102	ENGR	151	MOD	Change in Credit Exclusions.	FT 2025	NO	YES	TABLED		

PAGE	SUBJECT	COURSE #	ACTION	SUMMARY	EFFECTIVE TERM	MIN. GRADE REQ. FOR ENF. PREPREQ	Is Course on LSA Course Guide?	APPROVED	NOTES & REVISIONS	TABLED
105	MATSCIE	506	NEW		WT 2025	NO	NO	TABLED	Cross listed with CHE 506 and MACROMOL 506.	
115	MATSCIE	509	NEW		WT 2025	NO	NO	TABLED	Cross listed with BIOMEDE 509, CHE 509, and MACROMOL 509.	

UNIVERSITY OF MICHIGAN
College of Engineering
Curriculum Committee Meeting
Tuesday, February 13, 2024

Attending: Achilleas Anastasopoulos, Robert Bordley, Yavuz Bozer, Chris Fidkowski, Fei Gao, Vineet Kamat, Amir Kamil, Leena Lalwani, Xiaogan Liang, Emmanuelle Marquis, Frank Marsik, Radoslaw Michalowski, Yulin Pan, Mika Panagou, Rachael Schmedlen, Ben Spector, Elyse Vigiletti, Roxanne Walker

Support Staff: Mercedes Carmona, Betsy Dodge, Matthew Faunce

Call to Order: 1:35 PM

Adjourned: 2:41 PM

Agenda:

1. Approval of 1.30.2024 Meeting Minutes - Page 3 - **APPROVED**
2. HLC Annual Audit Questions 3 & 4 for the CoE Curriculum Committee – Informational Item – Page 6 - **PENDING**
    a. Review UM Academic Unit Credit Hour Policies Document & HLC Discussion Draft Document created by the Chair, which contains all UM schools/colleges credit policies and highlights aspects discussed with the HLC Annual Audit Questions 3 & 4.
        i. The main changes made to the CoE Credit Policy are more information for laboratory sections and Hybrid and Online courses and a new section added for courses that do not fall into the categories already listed in the policy.
            1. EECS - CSE: Suggestion of removing Special Topics from the policy as this doesn't fit well with the section it is listed with. Courses are in development for the first or second time before becoming official and should be adjusted by the instructor and department once the course is permanent. These courses should not have the ability to violate the policy.
            2. UG Education: The Hybrid and Online courses section sentence that begins with, "…and an equivalent amount of instructor led instruction as required by in-person lecture sections is provided." Do online courses still need to be instructor led in some capacity?
                a. Chair/MECHENG: This has been the ongoing conversation that has been hard to define and where the boundary lies with online teaching. There needs to be an equivalent amount of instructor led teaching to represent the credit hour and be consistent with the credit hour policy.
                b. UG Education: If courses needed to prove online learning is align with the policy, can this be done in the form of instructors reviewing Piazza and GSI offered to assist students with incoming questions?
                c. Chair/MECHENG: Yes.
                    i. Similar question raised by ROB, but regarding laboratory remote learning and if there needs to be a remote instructor/GSI. Same response given by Chair/MECHENG that this needs to be synchronous and is more specified within the last sentence of the laboratory section in the revised policy. Could possibly be more specified, if necessary, in the policy.
                d. CLIMATE & SPACE: Can this sentence be removed as it sounds redundant to what has already been said or what is the reasoning for this?
                    i. UG Education in agreement with the sentence removal, but TCHNCLCM finds this helpful in further explaining what is required from hybrid and online courses.
                    ii. Chair/MECHENG: This sentence specifically answers the HLC Annual Audit Question 4.

3. ISD: Input measures as opposed to outcomes, such as students who take longer to grasp the course material versus others that learn the material quickly. How would this be monitored?
    a. Chair/MECHENG: Consider the feedback from the students (i.e., lectures are pointless, read the textbook to learn the material). Figure out what is the best method to teach the course for students to be successful and learn the course outcomes/goals.
4. EECS - CSE: Lecture recordings should not count as contact hours. Instructors posting old recordings and considering this as contact hours. CSE has courses that have multiple sections and due to capacity with rooms there are options for students to choose for lecture, such as in-person or remote, that still includes students for the interaction needed. Students who watch old recordings do not get the interaction needed to count as a contact hour.
    a. ISD: Some courses have lectures that are all pre-recorded and these are not updated or revised and follow the rest of the curriculum given online. No interaction given and credit is still given.
    b. Chair/MECHENG: If the course only involves watching recordings, then this is not compliant with the policy. Courses that have assignments that are associated with recordings count towards the policy as this is enough interaction for the student's online learning.

b. All CoE CC members have access to the HLC Discussion Draft Document so if there is a new idea, revision, etc. that can be left in a comment, it is encouraged to do so that everyone contributes to this revision of the credit policy. This topic will continue at the next meeting on 3.12.2024.

3. CoE/LSA Joint Meeting Agenda Items – Informational Item - **PENDING**
    a. We are reaching out to ADUE and LSA to determine if a joint meeting is of interest between both colleges and determining what topics are to be discussed.
        i. Are the following topics discussed thus far enough to have a joint CoE/LSA Meeting?
            1. Graduate Education to follow up with documentation of SUGS information to provide to LSA, if this is still a topic of interest.
                a. Graduate Education to reach out to CLIMATE AND SPACE about the programs that are to be included for the SUGS Information, which still needs time to be gathered to present.
            2. Incomplete Grade Policies and Course Withdrawals and the LSA I-Grade Policy
                a. RO Office: The Bulletin contains information on CoE's the Incomplete Grade Policy which states that at least 70% of the work for a course needs to be completed for an instructor to be able to apply an I grade for a student.
                    i. On the Bulletin website, this information is under the tab Academic Rules and Grades and Scholastic Standing.
                b. Same sentiments brought forward by CEE, TCHNCLCM, CLIMATE & SPACE, MATSCIE, and Chair/MECHENG that the I grade is a negative mark for a student and shouldn't be listed on a transcript.
                c. IOE: Not all situations are the same for students to receive an I grade and not in agreement that every I grade should disappear.
                    i. Graduate Education: There is some context that needs to be given in a situation such as a student's independent research expanding to another semester and reviewing an IA versus IB grade.
                    ii. IOE: Same as not completing work on time and submitting homework late. If a student is inconsistent with their work, then they should be graded because of that.
                    iii. EECS-CSE & MATSCIE in agreement that students should not have to reveal their personal and private reasons as to why they cannot complete the course. The reasoning needs to be justifiable to give an I grade but shouldn't have to ask students for a reason if they are not comfortable with giving this information.
                    iv. CLIMATE & SPACE: Sometimes it is best for the student to walk away with the low grade rather than give an I grade.
                d. More information needs to be gathered, so discussions will continue regarding CoE Incomplete Grade Policies and Course Withdrawals and the LSA I-Grade Policy at the next meeting on 3.12.2024.
            3. CEE suggested finding out if LSA has any topics to discuss to see if this mirrors with anything CoE may have.

CARF SUMMARIES

PAGE	SUBJECT	COURSE #	ACTION	SUMMARY	EFFECTIVE TERM	MIN. GRADE REQ. FOR ENF. PREPREQ	Is Course on LSA Course Guide?	APPROVED	NOTES & REVISIONS	TABLED
12	IOE	435	MOD	Change in Course Description, Full Term Credit Hours, Course Credit Type, and Enforced Prerequisite.	WT 2025	C-	YES	APPROVED	Cross listed with ROB 435.	
15	IOE	535	NEW		WT 2025	NO	NO	APPROVED	Cross listed with ROB 535.	
40	ROB	298	NEW		FT 2024	NO	NO	APPROVED		
43	ROB	311	MOD	Change to Course Description and Advisory Prerequisite.	FT 2024	C-	YES	APPROVED		
47	ROB	330	MOD	Change to Course Description.	FT 2024	C-	YES	APPROVED		
50	ROB	498	MOD	Change in Repeatability and Course Components.	FT 2024	NO	YES	APPROVED		

MEMO

To: Curriculum Committee, College of Engineering

From: Radoslaw L. Michalowski
Chair, CEE Curriculum Committee

Date: February 19, 2024

Subject: Timeline for implementing and the impact on students of the Proposed Program Modifications to the Master of Science Degrees in:

Civil Engineering
Environmental Engineering
Construction Engineering & Management

Note: This Memo was written in consultation with Prof. Jeffrey Scruggs, the author of the document outlining the proposed modifications.

The ideal scenario for transition to the 26-credit MS programs would be to implement the change in between the Fall 2024 and Winter 2025 semesters, and notify students of it several months prior to its implementation. We envision that all students currently enrolled in the program would be able to take advantage of the new requirements. The rationale for this is that it would be minimally-disruptive. Specifically:

- The majority of our students matriculate in the Fall semester. For students who matriculate in Fall 2024, they would be notified of the reduction in credits in time to adjust their schedules for Winter 2025, if they choose to do so.

- Students who had already completed 26 credits (and met all graduation requirements) prior to the Winter 2025 would be able to graduate without having to register for Winter 2025.

- Students admitted for Fall 2025 would be notified of the change in credits prior to making the decision to attend.

While the above plan is our "ideal" scenario, we fully recognize that the details of the transition timeline would need to be planned in close coordination with administrators at Rackham. It may be that there are constraints and procedures that prohibit this plan from being implemented. However, we do suggest that whenever the transition is made, students should be notified of it several months prior to implementation.

MEMO – Amendment to the Memo of February 19, 2024

To: Curriculum Committee, College of Engineering

From: Radoslaw L. Michalowski
Chair, CEE Curriculum Committee

Date: March 1, 2024

Subject: Timeline for implementing and the impact on students of the Proposed Program Modifications to the Master of Science Degrees in:

Civil Engineering
Environmental Engineering
Construction Engineering & Management

Note: This Memo was written in consultation with Prof. Jeffrey Scruggs, the author of the document outlining the proposed modifications.

If more time is needed to implement the proposed changes, the transition could be implemented between Winter 2025 and Fall 2025. In this case, we recommend that the plan for the change be publicized by January 2025, so that it should apply retroactively to all students currently enrolled in CEE MSE programs. This will provide most students with enough time to make adjustments to their Winter 2025 programs of study, if necessary.

Proposed Program Change to the Master of Science Degrees in:
Civil Engineering
Environmental Engineering
Construction Engineering & Management

Abstract

The motivation for this proposed program change is to revise the MS degrees offered by the Department of Civil & Environmental Engineering to be optimally responsive to the current needs and expectations of our practice-bound MS students, without compromising the academic rigor and strong technical preparation the programs currently deliver. To this effect, we propose that the number of credit hours required for the MS degrees in Civil Engineering, in Environmental Engineering, and in Construction Engineering & Management be changed from 30 credits to 26. The Rackham Graduate School presently imposes a 30-credit minimum requirement for all Engineering degrees. As such, implementation of this change would require not only the modification to the degree requirements, but would also require that the Rackham minimum credit requirement be reduced to 26, to be commensurate with these changes. The rationale for this proposed change is that it makes it realistic for most MS students to complete their degree in two semesters, by taking four 3-credit courses plus a 1-credit seminar each semester. This is in contrast to the present 30-credit degree, which typically requires three semesters to complete. We feel that the change can be implemented with no substantive compromise to the technical rigor and scope of the degrees. We feel that making this change would be a dramatic and tangible benefit to students, not only because it would make the degrees more affordable, but also because it would halve the time from matriculation to graduation. Meanwhile, the change would also make these Masters degree programs more competitive with other leading Masters programs across the country, which would enable us to more effectively grow the programs.

Background

The Civil, Environmental, and Construction Engineering professions increasingly require a level of technical expertise which is beyond what can realistically be achieved in a four-year undergraduate degree. While the value of a Masters degree is universal across almost all areas of Engineering, it can be argued that in Civil and Environmental Engineering, especially, it is advantageous for a successful career in practice. This is because the undergraduate degrees in Civil and Environmental Engineering emphasize the full breadth of these professions, which involve a wide array of technical sub-fields (including but not limited to structural and geotechnical engineering, hydraulics, construction engineering and project management, transportation, wastewater treatment, biological process engineering, and environmental chemistry) with very little overlap, either in their techniques or their underlying physical principles. In exit interviews with our graduating seniors, the feedback is almost universal that they would have preferred to have specialized more in one branch of the degree (such as structural engineering, transportation engineering, water resources engineering, etc.). Although we have made every effort to address this feedback by providing a more versatile degree, we are heavily constrained by accreditation requirements imposed by the Accreditation Board for Engineering and Technology (ABET), to hew closely to the broad-based program requirements we presently have. As such, it is very common for students to continue with a Masters degree, prior to embarking on their careers, in order to get the baseline knowledge and expertise they need in their specialization area.

The University of Michigan is certainly not unique in this regard. Indeed, there is a growing trend across the country toward the view of the Masters degree as the entry-level degree for Civil and Environmental Engineering professions. For a number of years, the American Society of Civil Engineers (ASCE) has advocated for this position, and has proposed that a Masters degree be a requirement for a Professional

Engineer (PE) license. As this trend evolves, it is important that the University of Michigan be positioned in such a way as to provide a MS degree program which is commensurate with the needs and expectations of primarily industry-bound students. This is important because it ensures that students graduating from our program will be satisfied with their investment, which in turn solidifies the reputation of the degree. It is also important because it assures that we remain competitive with peer institutions.

Rationale for the Proposed Change

The Civil & Environmental Engineering (CEE) Department at the University of Michigan has always been successful at attracting MS students to our program, who are interested in research and who see the MS degree as a gateway to the PhD. Although research experience has never been a required component of our MS degree, many of these students get involved in research, either for credit (via independent study) or else in a less formal way. A full courseload is considered to be 12-13 credits (including independent study credits) and consequently, under the 30-credit degree requirement, these students almost never complete their degree in two semesters. Instead, with 24-26 credits completed at the end of their first year, they must find something to do over the summer, and come back the following Fall semester to complete the remaining 4-6 credit hours. (Note that it is almost never the case that these students can find relevant graduate-level coursework to complete their degrees over the spring or summer terms.) This means that the majority of our MS students complete their degrees off-cycle, with respect to PhD recruitment, and must wait until the following Fall to matriculate to a PhD program (either at UM or elsewhere). To make the most of this "lost year" many MS students pursue a dual degree or some other credential offered by the University, assuming that they can afford a fourth semester of tuition. Others find some kind of temporary employment. Regardless, it is our opinion that this fundamentally disadvantages our research-bound MS students, who would be much better served by a program that provides a path to degree completion which is synchronized with the PhD recruitment cycle.

However, the vast majority of students pursuing MS degrees leave academia after obtaining them, to start their professional careers. In order for our MS program to be successful, it is important that it be tailored to accommodate the needs and expectations of this cohort of students as well. These needs and expectations are fundamentally different from those of PhD-bound students. By and large, terminal Masters students view the MS degree as a career pathway, as much if not more than as a learning experience. For students with this viewpoint, they are looking for the graduate program that provides the most tangible value, in return for their investment. This value manifests itself in the new skill set they come away with, the increased salary that is commensurate with this skill set, and the shortness of the time it takes them to acquire it. Our MS program in CEE presently does exceptionally well at providing the skill set these students want, and the reputation of our degree is commensurate with the salary they expect. However, the combination of the time and expense required to obtain an MS degree at the University of Michigan are simply not competitive with many of our peer institutions.

Below are three examples, which also happen to be three of the very top CEE programs in the country. Note that in all cases, as with the present MS degrees in CEE offered at UM, these are coursework-only (i.e., non-thesis) degrees. This reflects a national trend away from thesis-based MS degrees in CEE. Also note all the MS programs described below are gateways to the PhD programs, in addition to serving terminal-MS students.

- University of California, Berkeley. UC Berkeley is widely regarded as one of the very best graduate programs in the country, for both Civil and Environmental Engineering. It is widely respected as the "gold standard" both within academia as well as in industry. The most recent US News rankings list it as the #1 graduate program for Civil Enginering, and #2 in Environmental Engineering. Some of our top undergraduate students have gone to UC Berkeley for their MS degrees. They offer a 24-credit MS degree that can be completed in 8 months. Each semester, students take four courses.

- Stanford University. The reputation of Stanford's graduate program in Civil and Environmental Engineering is outstanding, and it is often listed as one of the top four or five institutions for these degrees. Last year, UM CEE was tied with Stanford for #4 in the US News ranking of graduate programs in Civil Engineering, while Stanford's graduate program in Environmental Engineering ranked #1. Stanford is on the quarter system, and students pursuing MS degrees in Civil and Environmental Engineering complete them in three quarters (9 months).
- University of Illinois, Urbana-Champaign. For Civil and Environmental Engineering, UIUC is often listed as a top program, together with UC Berkeley and Stanford. Last year its US News rankings for graduate programs were #3 in Environmental (tied with UM), and #2 in Civil Engineering. Students pursuing a MS degree at UIUC complete the degree in 11 months. Technically, this degree takes longer than two semesters, because it includes a practicum program that students complete in the summer following two semesters of coursework.

It is true that some programs in the US have similar credit and time requirements, to those in place at UM. For example, at both Georgia Tech and the University of Texas, Austin, the degree typically takes 16 months (i.e., 3 semesters) to complete. (Last year Georgia Tech's MS degree in Civil Engineering ranked #3 in US News, while its Environmental Engineering MS degree ranked #5. Meanwhile, UT Austin's programs were ranked #6 and #3, respectively.) However, the total cost of tuition for these institutions is less than half that of a three-semester UM MS degree. As such, even though the time to the degree is the same, we still lose many of our best applicants to these programs.

The decision faced by practice-bound prospective students to our MS program is made even more stark when one considers the opportunity cost they pay by choosing a 16-month degree, over a 8 or 10-month degree. Typical starting salaries for MS graduates with degrees in Civil or Environmental Engineering are around $72k, and many graduates from top programs command salaries higher than the average. When weighing an 8-month program (like UC Berkeley) against a 16-month program (like U Michigan), an economically-minded prospective student will factor into their decision the fact that if they choose the 8-month program, they can start earning that salary 8 months earlier. When viewed in this light, the economic case for a shorter time to a degree becomes even more persuasive.

We conclude that, by reducing the credit hours of the MS degree from 30 to 26, the CEE Department would be dramatically lowering significant barriers faced by prospective students interested in pursuing an MS degree. As a consequence, doing so would greatly enhance the degree's accessibility. It is worth noting that this is especially true for students who have experienced financial hardship, students who have taken nontraditional paths toward their education, or who have other commitments in their lives that make their time-to-degree of particular importance. As such, in addition to the positive impacts already discussed, the proposed change is also likely enhance the diversity of our graduate student body. Moreover, it will allow us to better use our financial resources and provide full rides to a cohort of diverse students. For example, the department's Pelham Scholars program provides two (not three) semesters of tuition. Also, the Rackham Merit Award for MS students only provides two semesters of support.

Implementation Plan

We believe we can reduce the credit requirement from 30 to 26, while having essentially no adverse impact on the level of preparation we provide our students. The reason for this stems from the fact that, prior to 2018, the Rackham graduate school required all MS students to take four credits of cognate, in an area other than their chosen major. In 2018 the cognate requirement was discontinued for MS degrees, although the 30-credit requirement for Engineering MS degrees has remained unchanged. As such, students prior to 2018 were effectively only taking 26 credits of technical coursework that can be viewed as directly relevant to their professional preparation. By reducing the total credit requirement from 30 to 26, we can therefore offer exactly the same level of technical rigor and scope for the degree as we did prior to 2018, simply by eliminating the previously required cognate courses.

Indeed, the above observation makes the implementation of a 26-credit MS degree very straight-forward. Copies of the current MS Degree Guidelines for the Department's three MS degrees are attached. We propose each degree be modified as follows:

- **MSE in Civil Engineering**: The current degree requires students to take 12 credits of "specialization core" courses, 6 credits of "specialization elective" courses, and 12 credits of general electives and/or seminars in technical areas of their choice, with a maximum of 2 seminar credits. In the revised 26-credit degree, the general elective/seminar credits would be reduced from 12 to 8.
- **MSE in Environmental Engineering**: The current degree requires students to take 6 credits of "core" courses, 12 credits of "major" courses, 1 credit of seminar, and 11 credits of general electives in technical areas of their choice. In the revised 26-credit degree, the general elective credits would be reduced from 11 to 7.
- **MSE in Construction Engineering and Management**: The current degree requires students to take 12 credits in core CEM courses, 9 credits of CEM electives, 3 credits of Business-oriented coursework, 3 credits of Mathematics-oriented coursework, and 3 credits of general elective coursework in a technical area of their choice. In the revised 26-credit degree, the general elective would be eliminated, and the CEM electives would be reduced from 9 to 8, with students being permitted to take up to 2 credits of seminar.

Implications for SUGS Students

The SUGS program in CEE presently requires a 3.2 undergraduate GPA for consideration, and allows for students to double-count 6 credits from their undergraduate degree, toward their MS degree. These programmatic requirements will remain unchanged.

Impact on MEng Degrees

The CEE Department currently offers three 26-credit Master of Engineering (MEng) degrees through the College of Engineering. The proposed changes to the MS degree would impact each of these degrees in different ways:

- **MEng in Structural Engineering**: The primary appeal of this degree, relative to the MS degree in Civil Engineering, is that it can be completed in 8 months. As such, the proposed changes would effectively make this degree redundant, and it would be discontinued immediately.
- **MEng in Smart Infrastructure Finance**: This degree is offered by the CEE Department, but has a core curriculum that is highly cross-disciplinary, and serves a distinct cohort of students. The degree will continue to be offered without modification.
- **MEng in Construction Engineering and Management**: This degree has some fundamental distinctions, relative to the MS degrees in Construction Engineering and Management. In particular, the degree allows for students to complete six credits remotely and at a greatly-reduced cost, through online course modules. This results in a financial advantage because students can pay the lower tuition associated with a reduced courseload during their second semester. This degree will therefore continue to be offered, as the Department continues to move into the new market of online degrees and credentials.

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September 12, 2023

To whom it may concern:

I am writing to express my strong support for the proposed program change in the MS degrees offered by the Department of Civil & Environmental Engineering (CEE). As the Department Chair, I believe this change will allow us to better meet the evolving needs and expectations of our practice-bound MS students while upholding the academic rigor and technical preparation for which our programs are renowned. The proposal has been reviewed internally by the CEE Graduate Committee and Curriculum Committee, and was approved unanimously at our most recent Departmental Faculty Retreat on May 12, 2023. As such, it clearly has broad-based support among CEE faculty.

The proposed change suggests modifying the number of credit hours required for the MS degrees in Civil Engineering, Environmental Engineering, and Construction Engineering & Management from 30 credits to 26 credits. Implementation of this change would require reducing the Rackham Graduate School's minimum credit requirement from 30 to 26, in line with the proposed adjustments. The rationale behind this proposed change is to enable most MS students to complete their degrees within two semesters, by taking four 3-credit courses and a 1-credit seminar each semester. Currently, the 30-credit degree structure typically necessitates three semesters to fulfill all requirements. By reducing the credit hours, we aim to make the program more feasible and efficient for our students without compromising the technical rigor and breadth of knowledge imparted by our degrees.

We firmly believe that implementing this change would yield significant and tangible benefits for our students. Not only would it make the degrees more affordable, but it would also reduce the time from matriculation to graduation by half. This reduction in time-to-degree is highly advantageous for students, enabling them to enter the workforce or pursue further academic endeavors more expeditiously. Furthermore, the proposed change would enhance the competitiveness of our Masters degree programs, positioning them more favorably against other leading programs nationwide. This increased competitiveness would, in turn, facilitate the growth and expansion of our programs, allowing us to attract and retain top-tier students and faculty.

While the proposed program change seeks to reduce the credit hour requirement, we remain committed to maintaining the exceptional quality and academic excellence for which our department is renowned. The change is designed to optimize the program's responsiveness to the needs and expectations of our students in a rapidly evolving field, while ensuring they receive a comprehensive and rigorous education that prepares them for successful careers.

In conclusion, I wholeheartedly endorse the proposed program change for the MS degrees in Civil & Environmental Engineering. It will offer our students a more practical and

efficient path to degree completion, and will enhance the competitiveness and attractiveness of our programs. Should you require any further information or have any questions, please do not hesitate to contact me..

Sincerely,

Yafeng Yin, Ph.D.
Professor of Civil and Environmental Engineering
Professor of Industrial and Operations Engineering

Donald Malloure Department Chair
Department of Civil and Environmental Engineering
University of Michigan, Ann Arbor

MICHIGAN ENGINEERING
UNIVERSITY OF MICHIGAN

Lola Eniola-Adefeso, Ph.D.
Associate Dean for Graduate & Professional Education
Professor of Chemical Engineering, Biomedical Engineering,
Macromolecular Science and Engineering

December 28, 2023

Dear Colleagues:

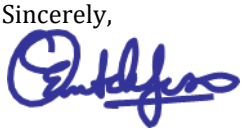
On behalf of Michigan Engineering and as Associate Dean for Graduate and Professional Education, I am pleased to provide this letter of support for the proposal put forth by the Department of Civil and Environmental Engineering (CEE), to reduce the required credits for their Master of Science in Engineering (MSE) degrees from 30 to 26. I understand that this change is significant. It will require the approval of the Rackham Executive Board (REB), because presently Rackham requires all degrees in Engineering to be at least 30 credits. I also understand that the change will require the approval of the Michigan Association of State Universities (MASU). However, I feel that the arguments in favor of this change are compelling.

First and foremost, making this change will allow our CEE Department to be competitive with its peer departments at institutions throughout the country, to attract the most talented and promising students. The Department has made a convincing case that the MSE programs of many of their top competitors offer degrees that can realistically be completed in less than a year. By contrast, presently, our MSE degrees typically require 16 months to complete, due to a shortage of relevant coursework available to students during the Spring semester. Shortening the time required to obtain the MSE degree affords numerous advantages. It results in a significant reduction in the cost of the degree, which makes it more accessible to a wider and more diverse group of prospective students, and it enables students completing the MSE degree to enter the workplace sooner, thus allowing them to begin reaping the returns on their educational investment sooner. For economically minded and industry-bound students, these points will likely be making a significant difference as they weigh their options for graduate education. Additionally, , a two-semester MSE degree would make it viable for our top MSE applicants to have the entirety of their graduate studies funded by our internal fellowships, such as the Rackham Merit Award and the CEE Department's Pelham Scholars Program, both of which provide funding for only two semesters. The proposed change also has positive implications for our PhD-bound students, as it will enable students to transition seamlessly from their completion of the MSE degree in the Winter semester, with matriculation into a PhD program the following Fall.

None of this would matter if the proposed reduction in credits fundamentally compromised the value of the education being received by our MSE students. However, CEE's proposal makes a convincing case that this is not a concern. As it points out, prior to 2018, Rackham required four credits of cognate coursework, in an area distinct from the student's specialization. This requirement has since been discontinued, although the 30-credit requirement has remained. It stands to reason that CEE students can receive the same level of technical preparation in their chosen area of specialization, to that they received prior to 2018, while taking four fewer credits of coursework. Of course, while it goes without saying that the academic experience of an MSE student would likely be enriched by enrolling in these extra four credits, it is considerably less convincing that this marginal value is offset by the doubling of the time to degree (i.e., from 8 to 16 months).

More generally, the purposes and expectations of the MSE degree have evolved and shifted in recent years. It is vital that we be cognizant of this changing landscape and modify our own graduate programs to keep pace. I believe that the programmatic change proposed by CEE serves as a good example, and I give it my strongest possible endorsement.

Sincerely,



Lola Eniola-Adefeso, Ph.D. (Fellow of AIMBE, BMES)
Associate Dean for Graduate & Professional Education
University Diversity and Social Transformation Professor of Chemical Engineering
Biomedical Engineering; Macromolecular Science and Engineering
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MASTER OF SCIENCE IN ENGINEERING (MSE) IN CIVIL ENGINEERING REQUIREMENTS AND PROCEDURES

The purpose of the MSE degree in Civil Engineering at the University of Michigan (U-M) is to permit a higher level of specialization than that achieved in a Civil Engineering undergraduate degree. These guidelines have been developed to assist graduate students working toward the MSE degree in Civil Engineering in planning a program of study that meets the requirements of that degree. Each student is responsible for planning such a study program, with the guidance and approval of the faculty advisor from their area of specialization. Faculty advisors are listed in Appendix 1.

1. REGULATIONS

The basic requirements for the MSE degree are established by the Horace H. Rackham School of Graduate Studies (referred to herein as the Graduate School). The faculty of the Department of Civil and Environmental Engineering has adopted certain additional requirements. The requirements, as they relate to the MSE in Civil Engineering degree, are described in these guidelines.

Each MSE student must take personal responsibility for seeing that all requirements are met prior to the graduation deadline specified by the Rackham Graduate School. These deadlines may be found at https://rackham.umich.edu/navigating-your-degree/apply-for-graduation/.

If special decisions or actions are needed, they should be initiated by the student in consultation with their specialization's faculty advisor and then referred to the CEE Masters Chair if necessary.

2. PROGRAM INFORMATION

2.1. Admission and Prerequisites

To be granted admission to the MSE in Civil Engineering degree program, an applicant normally holds a BSE degree in Civil Engineering and has attained an undergraduate grade point average (GPA) of at least 3.3/4.0. Students holding BS degrees in another engineering discipline, in architecture, or in the physical, chemical or biological sciences, may be admitted if they have achieved the technical background necessary to pursue advanced work in Civil Engineering. This background must include three semesters of calculus, one semester of ordinary differential equations, and two semesters of calculus-based physics. Courses at U-M which provide this background are listed below:

Prerequisite topic	UM courses
Calculus	MATH 115, 116, 215
Ordinary Differential Equations	MATH 216
Calculus-Based Physics	PHYSICS 140, 240

It is expected that incoming students will also have some prior experience with computer programming, and problem-solving using computers.

For each specialization area, additional prerequisites must be satisfied in order to take graduate courses pertaining to the specialization, as detailed in Appendix 1. Ideally, students should complete these undergraduate course requirements prior to applying. However, in special circumstances, and with the written approval of the faculty specialization advisor as well as the CEE Masters Chair, an admitted student with some prerequisite deficiencies may take the appropriate undergraduate courses *in the first offering of the course after*

enrollment for the MSE degree. It is necessary to obtain a grade of "B" or better in each of these courses. Otherwise it must be retaken. No prerequisite courses below the 400 level may be used for graduate credit. Prerequisite courses at the 400 level may be counted for graduate credit.

2.2. General Requirements and Policies

2.2.1. Credit Hours

A minimum of 30 credit hours of approved graduate work must be completed for the MSE in Civil Engineering degree. According to the Graduate School guidelines, a student must register for a minimum of nine credit hours per semester to be considered a full-time student. Nine to twelve credit hours per term is the usual full-time graduate course load. Graduate students with research or teaching appointments must carry a minimum of six credit hours per term.

Note that some U.S. government agencies, such as the Veterans Administration and the U.S. Citizenship and Immigration Services, may require a student to be enrolled for a different minimum number of credit hours to be considered a full-time student. International students must be enrolled full-time under requirements set by the U.S. Citizenship and Immigration Services, and on F-1 or J-1 visas should consult the International Center with any questions concerning enrollment, course registration, and visa status. International students who wish to be registered less than full-time must obtain permission in advance from the International Center or risk compromising their visa status.

2.2.2. Grades and GPA

A grade point average (GPA) of at least 3.0 must be maintained for graduate level courses taken while enrolled in the Graduate School, and for the 30 credit hours used to fulfill the credit-hour requirement. Failure to do so will result in being placed on probation. A course in which a grade lower than C is obtained may not be counted toward the satisfaction of any degree requirements, but it is considered in the computation of the overall GPA.

2.2.3. Thesis or non-thesis research

A thesis is not required, but up to 6 credit hours of research can be used toward the 30-credit hour degree requirement by electing the following independent study courses:

- CEE 910: Structural Engineering Research
- CEE 921: Hydraulic and Hydrological Engineering Research
- CEE 630: Directed Studies in Construction Engineering
- CEE 946: Soil Mechanics Research
- CEE 950: Structural Materials Research
- CEE 955: Transportation Systems Engineering Research
- CEE 970: Intelligent Systems Engineering Research

To register for any of these, the student must have a faculty sponsor and have worked out the details of what will be accomplished with that faculty member.

2.2.4. Language

Proficiency in the English language, both spoken and written, is expected. There is no requirement for proficiency in any other language. MSE applicants whose native language is not English must demonstrate English proficiency by following Graduate School guidelines (https://rackham.umich.edu/admissions/applying/tests/).

2.2.5. Residency Requirements

The Graduate School residency requirements are satisfied by full-time students being enrolled for two or more

semesters. Students pursuing the MSE in Civil Engineering degree on a part-time basis should become familiar with special requirements relating to part-time enrollment. See the website of the Graduate School at: https://rackham.umich.edu/policy/section5/

2.2.6. Time Limit

A student must complete all work within a period of five consecutive years after first enrollment in the Graduate School.

2.2.7. Transfer Credits

The Graduate School guidelines permit transfer of up to half of the 30 credit hours required for the MSE in Civil Engineering degree from inter-university and intra-university sources combined, according to the following rules:

Graduate Credit

A maximum of 6 credit hours of graduate credit may be transferred from another institution. These must be approved graduate-level courses completed while enrolled in a degree program with a grade of B or better from an accredited institution approved by the Graduate School. Considerations of credit transfer will be made only upon written application of the student to the Graduate School through the Department of Civil and Environmental Engineering, and only after the student has established an overall graduate grade point average of B or better in resident work. Courses cannot be transferred for credit if already applied toward another degree, or if taken more than five years before the beginning of graduate study at U-M .

Pre-graduate Credit

Credit for courses taken by the student with a grade of B or better earned while an undergraduate in the U-M College of Engineering may be included in the student's graduate study program subject to the following: (1) credit was not used to meet any bachelor's degree requirement (including minors), (2) credit was earned no more than two years before formal admission to the Graduate School and (3) credit was earned in courses approved for graduate credit by the Graduate School. The student may request the transfer of such credits through the Department of Civil and Environmental Engineering after they have established an overall graduate grade point average of B or better in resident work.

2.2.8: Sequential Undergraduate-Graduate Studies (SUGS)

SUGS students with undergraduate specialization in any area of CEE may pursue an MSE degree in Civil Engineering. SUGS students are permitted to double count up to 6 credit hours, provided that (1) these credit hours are obtained with courses approved for graduate credit by the Graduate School, for which the student has received a grade of B or better, and (s) that they satisfy the requirements of the Program of Study as indicated in Section 3.3.

2.2.9: Diploma

To be considered and to be formally awarded the MSE in Civil Engineering degree diploma, a student must submit a formal application to the Office of Graduate Academic Records of the Graduate School. The deadline for the Graduate School to receive the degree application form is four weeks after the first day of classes in a full term and one week after the first day of classes in a half term. These dates can usually be found on the Rackham Graduate School web site http://www.rackham.umich.edu/.

2.3. Program of Study

Students need to meet with the faculty advisor for their area of specialization to plan a program of study prior to starting their first semester of coursework. (The list of faculty advisors for each area of specialization can be found on the first page of this document.) Following this meeting, each student must submit (via email) a Program of Study Form (Appendix 2) to the CEE Student Services (CEE-StudentServices@umich.edu) for

approval before the end of the second week of the student's first semester of enrollment. Any subsequent changes to the study plan must be approved by the faculty advisor, and the Program of Study Form must be re-submitted before the alternate coursework is completed.

The Program of Study will vary for each student, depending on their interests and the courses being offered in a given year. However, each Program of Study must meet the following requirements:

- A minimum of 18 credit hours of the total 30 credit hours required for the MSE in Civil Engineering must be courses offered by the Department of Civil and Environmental Engineering.

- A minimum of 12 credit hours of the total 30 credit hours required for the MSE. in Civil Engineering must be from the "core" course list of ONE area of specialization. Core courses associated with each area of specialization are listed in Appendix 1. If a student completed coursework in a prior degree program which is equivalent to one of the core courses in their specialization area, and obtained a grade of B or better, this course may be counted toward the completion of their core requirement.

- A minimum of 6 credit hours of the total 30 credit hours required for the MSE in Civil Engineering must be from the "specialization elective" course list of the student's chosen area of specialization. Specialization elective courses are listed in Appendix 1. **If a student takes more than 12 credits of coursework from the specialization core, these credits automatically count toward the specialization elective requirement.** If a student previously completed coursework equivalent to one of the elective courses in their specialization area, and obtained a grade of B or better, this course may be counted toward the completion of their elective requirement.

- Up to 6 credit hours of research may be applied toward the degree. Students electing to do so must first find a faculty sponsor who will oversee the research. The student and faculty member must then work out the details of what will be accomplished, and decide on the number of credits. The student must then enroll in one of the research courses listed in Section 3.2.3. When enrolling, this student should choose the supervising faculty member's sub-section of the research course.

- Students may count at most 2 credits of seminar toward their degree. Furthermore, all students specializing in Structural Engineering, Geotechnical Engineering, Construction Engineering and Management, and Transportation Engineering must enroll in at least one seminar course corresponding to their specialization. These courses are:

    - CEE 812: Structural Engineering Graduate Seminar
    - CEE 830: Construction Engineering and Management Seminar
    - CEE 840: Geotechnical Engineering Seminar
    - CEE 8xx: Transportation Engineering Seminar

- Beyond the 12 credits of specialization-core, 6 credits of specialization-electives, and required seminar (for some specializations), the remainder of the 30 credits of coursework toward the MSE degree in Civil Engineering can be fulfilled by any graduate courses in the areas of Engineering, Computer Science, Mathematics, Probability, Statistics, Physics, Chemistry, Biology, Architecture, or Business, subject to advisor approval.

- No more than 12 credits at the 400 level listed in the bulletin of the Rackham School of Graduate Studies can be counted toward the MSE degree in Civil Engineering. Of these 12 hours, a maximum of 9 hours can be courses offered by the Department of Civil and Environmental Engineering.

Appendix 1: Prerequisites, core courses, and specialization elective courses

Construction Engineering & Management Faculty Advisor: C. Menassa		
Prerequisites	Specialization Core	Specialization Elective
● CEE 312: Structural Engineering ● CEE 345: Geotechnical Engineering ● CEE 331: Construction Management ● CEE 351: Civil Engineering Materials	● CEE 531: Construction Cost Engineering ● CEE 532: Advanced Construction Management ● CEE 536: Project Planning, Scheduling and Control ● CEE 530: Construction Professional Practice	● CEE 435: Building Information Modeling ● CEE 504: Engineering Economics and Finance ● CEE 533: Engineering Process Modeling and Risk Analysis ● CEE 534: Construction Engineering, Equipment, and Methods ● CEE 537: Construction of Buildings ● CEE 538: Computer-Aided Project Management ● CEE 539: Modern Construction Management ● CEE 555: Sustainability of Civil Infrastructure Systems ● CEE 631: Construction Decisions Under Uncertainty

Suggested General Electives
The following courses are commonly taken by CE students specializing in Construction Engineering & Management:

- IOE 510 Linear Programming
- Math 450 Advanced Mathematics for Engineers
- Stat 412 Introduction to Probability and Statistics
- EECS 442 Computer Vision
- EECS 551 Mathematical Methods for Signal Processing
- EECS 556 Image Processing
- EECS 568 Mobile Robotics:Methods and Algorithms
- ACC 471 Accounting Principles
- ACC 551 Principles of Managerial Accounting
- FIN 425 Entrepreneurial Finance
- FIN 503 Financial Management
- FIN 563 Real Estate Development in Practice
- MO 414 Managing Change
- MO 412 Negotiation Strategy
- BL 582 Real Estate Law

Geotechnical Engineering Faculty Advisor: F. Garcia		
Prerequisites	Specialization Core	Specialization Elective
● CEE 345: Geotechnical Engineering	● CEE 540: Advanced Soil Mechanics ● CEE 543: Numerical Modeling in Geotechnical Engineering ● CEE 545: Foundation Engineering ● CEE 546: Slopes, Dams and Retaining Structures ● CEE 548: Geotechnical Earthquake Engineering	● CEE 428: Groundwater Hydrology ● CEE 446: Engineering Geology & Site Characterization ● CEE 510: Finite Element Methods in Solid and Structural Mechanics ● CEE 535: Excavation and Tunneling ● CEE 542: Soil and Site Improvement ● CEE 544: Rock Mechanics ● CEE 547: Soils Engineering and Pavement Systems ● CEE 549: Geoenvironmental Engineering

Suggested General Electives
The following courses are commonly taken by CE students specializing in Geotechnical Engineering::

- CEE 421: Hydrology and Floodplain Hydraulics
- CEE 504: Engineering Economics and Finance
- CEE 509: Theory of Elasticity
- CEE 511: Dynamics of Structures
- CEE 575 Sensing for civil infrastructure systems
- EARTH 408: Introduction to GIS in Earth Sciences
- EARTH 420: Introduction to Earth Physics
- EARTH 442: Earth Surface Processes and Soils
- EARTH 467: Stratigraphy and Basin Analysis
- EARTH 468: Data and Models
- EARTH 483: Geophysics/Seismology
- EARTH 525: Tectonophysics
- EARTH: Earthquakes & Faults
- EECS 442: Computer Vision
- EECS 556: Image Processing
- IOE 561: Risk analysis
- MATH 450: Advanced Mathematics for Engineers
- MECHENG: 412 Advanced Strength of Materials
- NAVARCH 551: Offshore Engineering 1
- STAT 412: Introduction to Probability and Statistics

Hydraulics and Hydrologic Engineering Faculty Advisor: J. Bricker		
Prerequisites	Specialization Core	Specialization Elective
● CEE 325: Fluid Mechanics ● CEE 421: Hydrology and Floodplain Hydraulics	● CEE 428: Groundwater Hydrology ● CEE 501: Tsunamis, Hurricanes and Floods ● CEE 520: Physical Processes of Land-Surface Hydrology ● CEE 521: Flow in Open Channels ● CEE 522: Sediment Transport ● CEE 524: Restoration Fundamentals and Practice in Aquatic Systems ● CEE 525: Environmental Turbulence ● CEE 526: Design of Hydraulic Systems ● CEE 527: Coastal Hydraulics ● CEE 590: Stream, Lake, and Estuary Analysis ● CEE 591: Environmental Fluid Mechanics	● MECHENG 520: Advanced Fluid Mechanics 1 ● MECHENG 521: Advanced Fluid Mechanics 2 ● MECHENG 523 (AEROSP 523): Computational Fluid Dynamics 1 ● MECHENG 624 or AEROSP 525: Turbulent Flow ● CEE 545: Foundation Engineering ● CEE 546 Slopes, Dams and Retaining Structures ● CEE 510: Finite Element Methods in Solid and Structural Mechanics ● CEE 511: Dynamics of Structures ● CEE 573: Data analysis in CEE

Suggested General Electives

The following courses are commonly taken by CE students specializing in Hydraulics & Hydrologic Engineering::

- EAS 520/521 (Fluvial ecosystems and lab)
- CEE 510 Finite Element Methods
- CEE 517 Reliability of Structures
- CEE 537 Construction of Buildings
- CEE 540 Advanced Soil Mechanics
- CEE 542 Soil and Site Improvement
- CEE 543 Numerical modeling in geotechnical engineering
- CEE 553 Infrastructure systems optimization
- CEE 555 Sustainability of civil infrastructure systems
- CEE 571 Linear Systems Theory
- CEE 575 Sensing for civil infrastructure systems
- IOE 561 Risk analysis
- CLIMATE 421/ EARTH 421 Introduction to Physical Oceanography
- CLIMATE 555/ SPACE 555 Spectral Methods
- NAVARCH 520 Intermediate Hydrodynamics
- NAVARCH 523 Numerical Marine Hydrodynamics
- NAVARCH 551 Offshore Engineering 1
- EAS 520 Fluvial Ecosystems
- EAS 531 Principles of GIS
- EAS 541 Remote Sensing
- EAS 558 Water Policy and Politics
- EAS 574 Sustainable Energy Systems
- URP 542 Environmental Planning
- URP 520 Introduction to Geographic Information Systems

Intelligent Systems Faculty Advisor: J. Scruggs		
Prerequisites	Specialization Core	Specialization Elective
● CEE 303: Numerical Methods in Civil Engineering ● CEE 373: Probability and Statistical Methods	● CEE 572: Dynamics of Infrastructure Systems ● CEE 575: Sensing for Civil Infrastructure Systems ● CEE 553: Infrastructure Systems Optimization ● CEE554: Data Mining in Transportation	● CEE 571: Linear System Theory ● CEE 573: Data Analysis in Civil and Env. Engineering ● CEE 576: Stochastic Systems ● EECS460: Control Systems Analysis and Design ● EECS 501: Prob. and Random Processes ● IOE 574: Simulation Design and Analysis ● IOE 651: Risk Analysis 1

Suggested General Electives:
Students specializing in Intelligent Systems are strongly encouraged to include several core classes from one of the other specializations in their programs of study, as general electives. In addition, the following courses from other departments are commonly taken by CE students specializing in Intelligent Systems:

- AEROSP 566: Data Analysis and System Identification
- AEROSP 567: Inference, Estimation, and Learning
- AEROSP 577: Data-driven & Reduced Complexity Modeling
- AEROSP 580: Linear Feedback Control Systems
- EECS 502: Stochastic Processes
- EECS 544: Analysis of Societal Networks
- EECS 550: Information Theory
- EECS 551: Matrix Methods for Signal Processing, Data Analysis and Machine Learning
- EECS 558. Stochastic Control
- EECS 561 (MECHENG 561): Design of Digital Control Systems
- EECS 562: (AEROSP 551). Nonlinear Systems and Control
- EECS 563: Hybrid Systems, Analysis, and Control
- EECS 564: Estimation, Filtering, and Detection
- EECS 565: Linear Feedback Control Systems
- EECS 566: Discrete Event Systems
- EECS 592: Foundations of Artificial Intelligence
- EECS 600 (IOE 600). Function Space Methods in System Theory
- IOE 510 (Math 561) (OMS 518): Linear Programming I
- IOE 511 (Math 562): Continuous Optimization Methods
- IOE 512: Dynamic Programming
- IOE 517: Game Theory and Operations Applications
- MECHENG 461: Automatic Control
- MECHENG 548: Applied Nonlinear Dynamics
- MECHENG 552: Mechatronic Systems Design
- MECHENG 555: Design Optimization
- NAVARCH 583: Adaptive Control

Structural and Materials Engineering Faculty Advisor: E. Filipov		
Prerequisites	Specialization Core	Specialization Elective
● CEE 312: Structural Engineering ● CEE 412: Matrix Structural Analysis[1] ● CEE 413: Design of Metallic Structures[1] – or – CEE 415: Design of Concrete Structures[1] ● CEE 351: Civil Engineering Materials[2] ● CEE 345: Geotechnical Engineering[3]	● CEE 510: Finite Element Methods ● CEE 511: Dynamics of Structures ● CEE 512: Nonlinear Analysis of Structures ● CEE 513: Plastic Analysis and Design of Frames ● CEE 514: Prestressed Concrete ● CEE 515: Advanced Design of R/C Structures ● CEE 517: Reliability of Structures ● CEE 547: Soils Engineering and Pavement Systems ● CEE 611: Performance Based Earthquake Engineering	● CEE 516: Bridge Structures ● CEE 518: Deployable and Reconfigurable Structures ● CEE 545: Foundation Engineering ● CEE 572: Dynamics of Infrastructure Systems ● CEE 575: Sensing for Civil Infrastructure Systems ● CEE 616: Passive Control of Structural Systems ● CEE 6xx: Structural Fire Engineering ● CEE 650: Adv. Fiber R/C for Sustainable Infrastructure ● CEE 554: Data Mining in Transportation ● IOE 574: Simulation Design and Analysis ● IOE 651: Risk Analysis 1 ● CEE 553: Infrastructure Systems Optimization ● CEE 573: Data Analysis in CEE

[1] Students taking these prerequisite courses during their MSE degree may count them toward the 30-credit degree, as general electives, provided that only 9 credit hours of 400-level CEE courses are counted towards their degree.
[2] Only required for students electing to take CEE 547 or CEE 650
[3] Only required for students electing to take CEE 545

Suggested General Electives
The following courses are commonly taken by CE students specializing in Structural and Materials Engineering:

- CEE 435: Building Information Modeling
- CEE 509: Theory of Elasticity
- CEE 546: Slopes, Dams and Retaining Structures
- CEE 547: Soils Engineering and Pavement Systems
- CEE 548: Geotechnical Earthquake Engineering
- CEE 555: Sustainability of Civil Infrastructure Systems
- CEE 571: Linear System Theory
- ARCH: 524 Surface Structures
- ARCH: 544 Wood Structures
- ARCH: 571 Digital Fabrication
- AERO: 416 Plates and Shells
- AERO: 516 Mechanics of Composites
- AERO: 518 Theory of Elastic Stability I
- MSE: 514 Composite Materials

- MECHENG: 412 Advanced Strength of Materials
- MECHENG: 511 Theory of Solid Continua
- MECHENG: 555 Design Optimization
- MECHENG: 605 Adv. Finite Element Methods in Mech.

Transportation Systems Engineering Faculty Advisor: N. Masoud		
Prerequisites	Specialization Core	Specialization Elective
● CEE 303: Numerical Methods in Civil Engineering ● CEE 373: Probability and Statistical Methods ● CEE 450: Introduction to Transportation Engineering	● CEE 551: Traffic Science ● CEE 552: Travel Behavior Analysis and Forecasting ● CEE 553: Infrastructure Systems Optimization ● CEE 554: Data Mining in Transportation ● CEE 557: Large-scale Transportation Systems Optimization ● CEE 559: Transportation Network Modeling	● CEE 572: Dynamics of Infrastructure Systems ● CEE 577: Dynamics and Control of Connected Vehicles ● CEE 547: Soil Engineering and Pavement Systems ● URP 560: Transportation and Land Use Planning ● URP 561: Public Policy and Transportation ● AEROSP 740: Air Transportation Systems ● CEE 575: Sensing for Civil Infrastructure Systems

Suggested General Electives
The following courses are commonly taken by CE students specializing in Transportation Engineering:

- CEE 571: Linear System Theory
- CEE 576: Stochastic Systems
- EECS 460: Control Systems Analysis and Design
- EECS 592: Foundations of Artificial Intelligence
- IOE 511 (Math 562): Continuous Optimization Methods
- IOE 512: Dynamic Programming
- IOE 515: Stochastic Processes
- IOE 517: Game Theory and Operations Applications
- IOE 561: Risk Analysis
- IOE 610 (Math 660). Linear Programming II
- IOE 611 (Math 663). Nonlinear Programming
- IOE 612. Network Flows
- IOE 614. Integer Programming

Appendix 2: Plan of Study

Student's Name: _____

Specialization: _____

	Semester				Credit Hours
	F___	W___	F___	W___	
Specialization core (min 12 credit hours)					
1.					
2.					
3.					
4.					
Specialization electives (min 6 credit hours)					
1.					
2.					
3.					
General electives & seminars					
1.					
2.					
3.					
4.					
5.					

- ❑ At least 18 credit hours of CEE courses.
- ❑ No more than 9 credit hours of 400-level CEE courses.
- ❑ No more than 12 credit hours of 400-level courses in total.
- ❑ No more than 2 credit hours of seminar

❑ Check here if you are a SUGS student. Please attach your approved SUGS form.

Faculty Advisor: _____ (signature) Date: _____

COLLEGE OF ENGINEERING
CIVIL & ENVIRONMENTAL ENGINEERING
UNIVERSITY OF MICHIGAN
2350 Hayward ■ 2056 G.G. Brown ■ Ann Arbor Michigan 48109-2125

MASTER OF SCIENCE IN ENGINEERING (MSE) IN ENVIRONMENTAL ENGINEERING
REQUIREMENTS AND PROCEDURES

The purpose of the MSE degree in Environmental Engineering is to permit a higher level of specialization in Environmental Engineering than that achieved in an undergraduate degree. The Environmental and Water Resources Engineering (EWRE) program also offers the degree of MSE in Civil Engineering with a specialization in Hydraulics and Hydrology. Students interested in this program should consult the separate MSE in Civil Engineering guidelines.

These guidelines have been developed to assist graduate students working toward the MSE degree in Environmental Engineering in planning a program of study that meets the requirements of that degree. Each student is responsible for planning such a study program, with the guidance of a faculty advisor from the Environmental and Water Resources Engineering (EWRE) program faculty:

Peter Adriaens	Seth Guikema	Lissa MacVean
Jeremy Bricker	Valeriy Ivanov	Rachel O'Brien
Herek Clack	Joshua Jack	Lutgarde Raskin
Aline Cotel	Branko Kerkez	Jeremy D. Semrau
Glen Daigger	Christian Lastoskie	Alex Szczuka
Brian R. Ellis	Nancy G. Love	Krista Wigginton

1. REGULATIONS

The basic requirements for the MSE degree are established by the Horace H. Rackham School of Graduate Studies (referred to herein as the Graduate School). The faculty of the Department of Civil and Environmental Engineering has adopted certain additional requirements. The requirements, as they relate to the MSE in Environmental Engineering degree, are described in these guidelines.

Each MSE student must take personal responsibility for seeing that all requirements are met prior to the graduation deadline specified by the Rackham Graduate School. These deadlines may be found at https://rackham.umich.edu/navigating-your-degree/apply-for-graduation/.

If special decisions or actions are needed, they should be initiated by the student in consultation with their faculty advisor and referred to the EWRE Graduate Program Advisor for action.

2. PROGRAM INFORMATION

2.1. Admission and Prerequisites

To be granted admission to the MSE in Environmental Engineering degree program, an applicant normally holds a BSE degree in a traditional engineering discipline (e.g., civil, chemical, environmental, mechanical, etc.) and has attained an undergraduate grade point average (GPA) of at least 3.3/4.0. Students holding B.S. degrees in another engineering discipline, or a physical, chemical or biological science field, may be admitted if they have achieved the technical background necessary to pursue advanced work in Environmental Engineering. **This background includes three semesters of calculus, ordinary differential equations (ODEs), a semester of calculus-based physics, a semester of college chemistry, a semester of fluid**

mechanics, problem-solving work using computers, and some background in environmental process engineering. Students should have completed these requirements *prior to applying*. However, the requirements of ODEs, fluid mechanics, and exposure to environmental process engineering can be completed by taking the courses below *in the first offering of the course after enrollment for the M.S.E. degree.*

Prerequisite topic	UM courses
Ordinary Differential Equation	MATH 216
Fluid Mechanics	CEE 325
Environmental Process Engineering	CEE 465

It is necessary to obtain a grade of "B" or better in each of these courses. Otherwise it must be retaken. None of the courses listed above may be used for graduate credit.

2.2. General Requirements and Policies

2.2.1. Credit Hours

A minimum of 30 credit hours of approved graduate work must be completed for the MSE in Environmental Engineering degree. According to the Graduate School guidelines, a student must register for a minimum of nine credit hours per semester to be considered a full-time student. Nine to twelve credit hours per term is the usual full-time graduate course load. Graduate students with research or teaching appointments must carry a minimum of six credit hours per term.

Note that some U.S. government agencies, such as the Veterans Administration and the U.S. Citizenship and Immigration Services, may require a student to be enrolled for a different minimum number of credit hours to be considered a full-time student. International students must be enrolled full-time under requirements set by the U.S. Citizenship and Immigration Services, and on F-1 or J-1 visas should consult the International Center with any questions concerning enrollment, course registration, and visa status. International students who wish to be registered less than full-time must obtain permission in advance from the International Center or risk compromising their visa status.

2.2.2. Grades and GPA

A grade point average (GPA) of at least 3.0 must be maintained for graduate level courses taken while enrolled in the Graduate School, and for the 30 credit hours used to fulfill the credit-hour requirement. Failure to do so will result in being placed on probation. A course in which a grade lower than C is obtained may not be counted toward the satisfaction of any degree requirements, but it is considered in the computation of the overall GPA.

2.2.3. Thesis or non-thesis research

A thesis is not required, but up to 6 credit hours of research can be used toward the 30-credit hour degree requirement by electing CEE 921 Hydraulics and Hydrological Engineering Research or CEE 980 Research in Environmental Engineering. To register for either CEE 921 or CEE 980, the student must have a faculty sponsor and have worked out the details of what will be accomplished with that faculty member.

2.2.4. Language

Proficiency in the English language, both spoken and written, is expected. There is no requirement for proficiency in any other language. MSE applicants whose native language is not English must demonstrate English proficiency by following Graduate School guidelines (https://rackham.umich.edu/admissions/applying/tests/).

2.2.5. Residency Requirements

The Graduate School residency requirements are satisfied by full-time students being enrolled for two or more semesters. Students pursuing the MSE in Environmental Engineering degree on a part-time basis should become familiar with special requirements relating to part-time enrollment. See the website of the Graduate School at: https://rackham.umich.edu/policy/section5/

2.2.6. Time Limit

A student must complete all work within a period of five consecutive years after first enrollment in the Graduate School.

2.2.7. Transfer Credits

The Graduate School guidelines permit transfer of up to half of the 30 credit hours required for the MSE in Environmental Engineering degree from inter-university and intra-university sources combined, according to the following rules:

Graduate Credit

A maximum of 6 credit hours of graduate credit may be transferred from another institution. These must be approved graduate-level courses completed while enrolled in a degree program with a grade of B or better from an accredited institution approved by the Graduate School. Considerations of credit transfer will be made only upon written application of the student to the Graduate School through the Department of Civil and Environmental Engineering, and only after the student has established an overall graduate grade point average of B or better in resident work. Courses cannot be transferred for credit if already applied toward another degree, or if taken more than five years before the beginning of graduate study at U-M .

Pre-graduate Credit

Credit for courses taken by the student with a grade of B or better earned while an undergraduate in the U-M College of Engineering may be included in the student's graduate study program subject to the following: (1) credit was not used to meet any bachelor's degree requirement (including minors), (2) credit was earned no more than two years before formal admission to the Graduate School and (3) credit was earned in courses approved for graduate credit by the Graduate School. The student may request the transfer of such credits through the Department of Civil and Environmental Engineering after they have established an overall graduate grade point average of B or better in resident work.

2.2.8: Sequential Undergraduate-Graduate Studies (SUGS)

SUGS students with undergraduate specialization in any area of CEE may pursue an MSE degree in Environmental Engineering. SUGS students are permitted to double count up to 6 credit hours, provided that (1) these credit hours are obtained with courses approved for graduate credit by the Graduate School, for which the student has received a grade of B or better, and (s) that they satisfy the requirements of the Program of Study as indicated in Section 2.3.

2.2.9: Diploma

To be considered and to be formally awarded the MSE in Environmental Engineering degree diploma, a student must submit a formal application to the Office of Graduate Academic Records of the Graduate School. The deadline for the Graduate School to receive the degree application form is four weeks after the first day of classes in a full term and one week after the first day of classes in a half term. These dates can usually be found on the Rackham Graduate School web site http://www.rackham.umich.edu/.

2.3. Program of Study

Students need to meet with their faculty advisor to plan a program of study prior to starting their first semester of coursework. A Program of Study Form (Appendix 2) must be submitted to the EWRE Graduate Program Advisor for approval before the end of the second week of the student's first semester of enrollment. Prior approval of the plan must be obtained from the student's faculty advisor. The EWRE Graduate Program Advisor must approve any subsequent changes to the study plan before the alternate coursework is completed.

The Program of Study will vary for each student, depending on their interests and the courses being offered in a given year. However, each Program of Study must meet the following requirements:

- A minimum of 18 credit hours of the total 30 credit hours required for the MSE in Environmental Engineering must be courses offered by the Department of Civil and Environmental Engineering.

- To provide breadth in the fundamentals of environmental engineering, students must take at least *one course from two of the following three core categories (6 credits)*: C – Environmental Chemical Sciences, B – Environmental Biological Sciences, P – Environmental Physical Sciences:
  C: CEE 581 or CEE 597
  B: CEE 582 or CEE 693
  P: CEE 591 or CEE 590 or CEE 521
  For example, a student could select to take CEE 581 and CEE 582 to meet this requirement. If students have completed coursework equivalent to any of the above core courses before entering the Program, courses in any of the Majors described below may be substituted in consultation with the student's faculty advisor.

- An additional 12 credit hours must be selected in one of the following areas of study, or "Majors":
  Environmental Process Engineering
  Energy, Climate, and Air Quality
  Environmental Data Systems and Finance
  Ecohydrology and Environmental Fluid Mechanics
  The courses that may be selected to fulfill the Majors are listed in Appendix 1. If a student has already completed coursework equivalent to one or more courses listed in their chosen Major, with a grade of B or better, the Major can be satisfied with nine credit hours of coursework, but not research. CEE 421 Hydrology and Floodplain Hydraulics is a prerequisite for the Ecohydrology and Environmental Fluid Mechanics major. If the prerequisite for a major has not been taken previously, it must be taken and can be used to fulfill an elective in the major with a grade of B or better. CEE 421 requires additional work (to be worked out with the instructor in advance) to be counted for graduate credit.

- Up to six credit hours of research in hydraulics/hydrology (CEE 921) or environmental engineering (CEE 980) may be applied toward the degree. Enrollment in CEE 921 or CEE 980 can substitute for up to three credit hours of the coursework in the Major, but not the courses required for the Major.

- New M.S.E. students must complete an introductory seminar, CEE 881 (1 credit hour), in the first fall semester of the student's program. This is the only seminar credit that can be counted toward the degree. Registration in and attendance at CEE 880, the Program's seminar series, is required during each winter semester for all enrolled M.S.E. students. CEE 880 credit hours may not be counted towards the degree.

- A minimum of *11 credit hours* of elective coursework related to the degree is required. Any course listed as part of a major is acceptable as an elective. Students also often take graduate level courses elsewhere in CEE, the College of Engineering, or in other units such as the School of Environment and

Sustainability (SEAS) and Ross School of Business as electives.

- A 400-level course may be elected for graduate credit if the course is eligible for graduate credit. Within Civil and Environmental Engineering, *the following 400-level courses are eligible for graduate credit toward degrees in Environmental Engineering: CEE 428; CEE 421 is also eligible with additional work that needs to be worked out in advance with the course instructor*. Of all the 400-level courses elected, no more than a total of 12 credit hours, and no more than 9 credit hours of 400-level Civil and Environmental Engineering courses, will be accepted towards the degree.

Appendix 1: MSE Majors Guidelines

A total of 30 credit hours are required to complete the Environmental Engineering M.S.E. degree.

Each M.S.E. student must take the following seminar courses

CEE 881 (during their first fall semester, 1 credit)
CEE 880 (each winter semester student is enrolled, NFC)

Environmental Engineering Core Courses

Must take *at least* one course from two of three core categories (6 credits)

C: CEE 581 or CEE 597
B: CEE 582 or CEE 693
P: CEE 591 or CEE 590 or CEE 521

One Major or Elective course selection must be listed with a C, B, or P designation, whichever is not taken for the two core course elections. These designations indicate the course content has a significant emphasis on chemical (C), biological (B), or physical (P) science and/or processes. For example, if a student selects CEE 581 and CEE 582 as their courses to meet the requirements for the core in environmental engineering, they need to take at least one course with a P designation as part of their major or elective courses (e.g., CEE 580).

Note regarding research/independent study credit

Up to six credit hours of CEE 980 or CEE 921 can be taken as part of the MSE-required credit hours.

Major Area 1: Environmental Process Engineering

*If selecting this major, it is *recommended* that students take CEE 581 as one of their core courses or electives

Must take two of the following courses (6 credits)

CEE 580 Physical Chemical Processes in Environmental Engineering (C, P)
CEE 592 Biological Processes in Environmental Engineering (B)
CEE 563 Air Quality Engineering Fundamentals (P)

Must take two of the following courses (6 credits)

CEE 428 Groundwater Hydrology (P)
CEE 501.x Adapting to water scarcity: design of advanced treatment systems (C, P)
CEE 520 Physical Processes of Land-Surface Hydrology (P)
CEE 568 Decentralized Water Supply, Hygiene, and Sanitation
CEE 501 Engineering Solutions to Drinking Water Challenges (*new course number soon)
CEE 573 Data Analysis in CEE
CEE 597 Environmental Organic Chemistry (C)
CEE 624 Restoration Fundamentals & Practice in Aquatic Systems
CEE 693 Environmental Molecular Biology (B)
CEE 980 Research in Environmental Engineering (directed study related to Major)

Recommended electives (min of 11 credits)

Any of the above courses not yet taken
BiolChem 550 Intro to Biochemistry
ChE 496/ChE 696 Metabolic and Microbiome Engineering
ChE 540 Mathematical Methods for Biological Network Analysis

BIOINF 527 Introduction to Bioinformatics & Computational Biology
EARTH 523 Microbial Community Omics
EEB 446 Microbial Ecology
EEB 447 Microbes in the Wild: Environmental Microbiology Laboratory
EPID 582 Molecular Epidemiology
CLIMATE 466 Carbon – Climate Interactions
CEE 587 (NRE 558) Water Resource Policy
CEE 589 (NRE 595) Risk and Benefit Analysis in Environmental Engineering
CEE 575 Sensors, Data, and Intelligent Systems
EHS 674 Environmental and Health Risk Monitoring
EHS 608 Environmental Epidemiology
MICRBIOL 612
MECHENG 589 - Sustainable Design of Technological Systems

Major Area 2: Energy, Climate, and Air Quality

Must take two of the following courses (min 6 credits):
CEE 563 Air Quality Engineering Fundamentals (P)
CEE 564 / ESENG 535 Greenhouse Gas Control (P)
CEE 567 / ESENG 567 Energy Infrastructure Systems (P)

Must take one of the following courses, or a third course from the list above (min 3 credits):

CEE 428	Groundwater Hydrology (P)
CEE 526	Design of Hydraulic Systems (P)
CEE 555	Sustainability of Civil Infrastructure Systems
CEE 575	Sensors, Data, and Intelligent Systems
CEE 588 / CHE 590	Sustainability Finance: Investment Models for Green Growth
CEE 592	Biological Processes in Environmental Engineering (B)
CEE 597	Environmental Organic Chemistry (C)
CEE 980	Research in Environmental Engineering (directed study related to Major)

Recommended electives (min of 3 credits)
Any of the above courses not yet taken

APPPHYS 524 / EECS 524	Organic Electronic Devices and Applications
BE 527 / EAS 527	Energy Markets and Energy Politics
CEE 565 / ESENG 501	Seminars on Energy Systems Technology and Policy
CEE 586 / EAS 557	Industrial Ecology
CLIMATE 463	Air Pollution Meteorology
CLIMATE 466	Carbon-Climate Interaction
CLIMATE 473	Climate Physics (P)
CLIMATE 479	Atmospheric Chemistry (C)
CLIMATE 480 / EAS 480	Climate Change: The Move to Action
EARTH 529 / NERS 531	Nuclear Waste Management
EAS 525	Energy Justice
EAS 555	Climate and Development
EAS 573	Environmental Footprinting and Input-Output Analysis
EAS 574 / ESENG 532	Sustainable Energy Systems
EAS 575	Climate Economics and Policy
EAS 597	Environmental Systems Analysis

EAS 605	Green Development
EAS 615	Renewable Electricity and the Grid
EAS 686 / PUBPOL 563	Environmental Policy
EECS 418	Power Electronics
EECS 419	Electric Machinery and Drives
EECS 421	Properties of Transistors
EECS 429	Semiconductor Optoelectronic Devices
EECS 463	Power System Design and Operation
EECS 534	Distribution Systems
EECS 535	Power Systems Dynamics and Control
EECS 536	Power Markets
EHS 540	Sustainability and Environmental Health
ESENG 505 / MECHENG 571	Energy Generation and Storage Using Modern Materials
MATSCIE 545	Fundamentals of Battery Design
MECHENG 589	Sustainable Engineering and Design
NERS 524	Nuclear Fuels
NERS 546	Thermal Fluids for Nuclear Reactor Safety Analysis

Major Area 3: Environmental Data Systems and Finance

Must take one course from all three core course categories (one will count toward Major) (3 credits):

C: CEE 581 or CEE 597
B: CEE 582 or CEE 693
P: CEE 591 or CEE 590 or CEE 521

Must take (3 credits):

CEE 573 Data Analysis in Civil and Environmental Engineering
(*confer with Graduate Program Advisor if CEE 573 is not offered during your term of study to find an alternative course to satisfy this requirement)

Must take one of the following courses (3 credits):

EECS 545 Machine Learning (CSE)
EECS 553 Machine Learning (ECE)

Must take one of the following courses (3 credits)

CEE 504 Engineering Economics and Finance
CEE 553 Infrastructure Systems Optimization
CEE 555 Sustainability of Civil Infrastructure Systems

Recommended Electives (min. 11 credits)

CEE 428 Groundwater Hydrology (P)
CEE 500 Environmental Systems and Processes I

CEE 501.004 Infrastructure Project Finance (*new course number coming soon)
CEE 504 Engineering Economics and Finance
CEE 520 Physical Processes of Land-Surface Hydrology (P)
CEE 553 Infrastructure Systems Optimization
CEE 555 Sustainability of Civil Infrastructure Systems
CEE 563 Air Quality Engineering Fundamentals (P)
CEE 567 Energy Infrastructure Systems (P)
CEE 568 Decentralized Water Supply, Hygiene and Sanitation
CEE 575 Sensors, Data, and Intelligent Systems
CEE 580 Physicochemical Processes in Environmental Engineering (C, P)
CEE 588 (CHE 590) Sustainability Finance: Investment Models for Green Growth
CEE 590 Stream, Lake, and Estuary Analysis (P)
CEE 592 Biological Processes in Environmental Engineering (B)
IOE 512 Dynamic Programming
IOE 515 Stochastic Processes
IOE 561 (ISD 523) Risk Analysis I
IOE 574 Simulation Design and Analysis

Major Area 4: Ecohydrology and Environmental Fluid Mechanics
*If selecting this major, it is *required* that students take CEE 591 as one of their core courses or electives

Must take one of the following courses:
CEE 573 Data Analysis in CEE
AEROSP 523 Computational Fluid Dynamics I

Must take one of the following courses:
CEE 428 Groundwater Hydrology (P)
CEE 520 Physical Processes of Land-Surface Hydrology (P)
CEE 590 Stream, Lake, and Estuary Analysis (P)

Must take two of the following courses:
Any of the above courses not yet taken
CEE 501 Tsunamis, Hurricanes and Floods
CEE 521 Open Channel Flow (P)
CEE 522 Sediment Transport (P)
CEE 524 Restoration Fundamentals
CEE 526 Design of Hydraulic Systems (P)
CEE 563 Air Quality Engineering Fundamentals

Appendix 2: Student Plan of Study

Student's Name: _____

	Semester				Credit Hours
	F___	W___	F___	W___	
Core (6 credit hours)					
1.					3
2.					3
Major - _____ (min 12 credit hours)					
1.					
2.					
3.					
4.					
Electives (min 11 credit hours)					
1.					
2.					
3.					
Seminars					
1. CEE 880 (each Winter term of enrollment)		x		x	0
2. CEE 881 (first Fall term)	x				1

At least 18 credit hours of CEE courses. No more than 9 credit hours of 400-level CEE courses. No more than 12 credit hours of 400-level courses in total.

Check here if you are a SGUS student_____. Please attach your approved SGUS form.

Faculty Advisor: _____ (signature) Date: _____

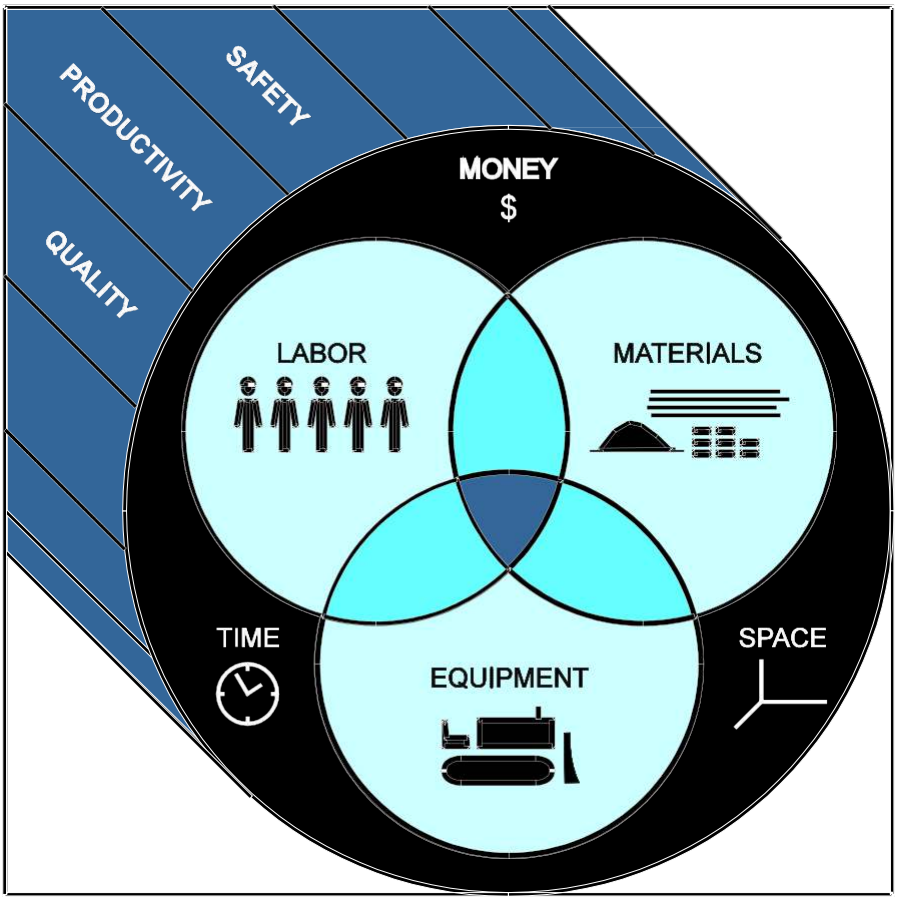
EWRE Graduate Advisor: _____ (signature) Date: _____

THE UNIVERSITY OF MICHIGAN

GRADUATE DEGREE PROGRAMS

Tishman Construction Management Program

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING



The **Master of Science in Engineering (MSE)** program in Construction Engineering and Management, established in 1954, pioneered construction graduate education. Graduates lead construction engineering and management organizations throughout the world. The **Master of Engineering (MEng)** program in Construction Engineering and Management, established in 1994, continues this tradition with its strong emphasis on the highest level of professional practice. The integration of theory and practice in construction engineering and management attracts practicing engineers as well as recent engineering graduates. The **PhD** program focuses on the doctoral students' dissertation research. Graduates have made significant contributions to knowledge in construction engineering and management and occupy academic and research positions at leading institutions worldwide.

The Michigan Engineer is taught to perform at the three functional levels of construction engineering and management:

Construction Organization — Form a construction company or department and organize and direct its marketing, financing, estimating, personnel, purchasing, quality assurance, accounting, and control functions.

Construction Project — Estimate, bid, plan, schedule, control and manage a project at a profit, including contract negotiations, material selection, purchasing, financing, personnel, labor relations, subcontract procurement and coordination, safety, quality assurance, accounting, and schedule and cost control functions.

Construction Operations — Plan and supervise construction operations, select and train crews, select and maintain equipment, select, fabricate, erect, install, and test materials, measure and analyze operations for improved safety and productivity.

THE UNIVERSITY OF MICHIGAN – TISHMAN CONSTRUCTION MANAGEMENT PROGRAM

MASTER'S DEGREE PROGRAMS

The **Master of Science in Engineering** in Construction Engineering and Management, abbreviated MSE (CE&M), is for students interested in combining research with construction professional practice, and who either wish to work in the construction industry or pursue a PhD following their Master's degree program. The MSE (CE&M) requires 30 hours of coursework that follows the program below.

CEE 531–Construction Cost Engineering	3 hr
CEE 532–Construction Project Engineering	3 hr
CEE 536–Critical Path Methods	3 hr
CEE 530-Construction Professional Practice OR	3 hr
CEE 630–Directed Studies in Construction	3 hr
Graduate CE&M Elective Courses	9 hr
Business, Industrial and Operations Engineering, or other management elective	3 hr
Mathematics, Probability, Statistics, Or Computer Science Elective	3 hr
Program Elective	3 hr
	30 hr

In addition to the above requirements, MSE (CE&M) students are strongly recommended to take the 1 hr CEE 830 CE&M Seminar.

The MSE (CE&M) program elective may be selected from graduate CE&M courses listed below, or from other areas such as those listed below as business or mathematics electives.

Most MSE (CE&M) students take a total of 24-27 hours in the Fall and Winter terms, and 3-6 hours in the Spring term or the following Fall term, completing their MSE (CE&M) program in 10-15 months of study.

The **Master of Engineering** in Construction Engineering and Management, abbreviated MEng (CE&M), is for students who are concentrating on state-of-the-art construction professional practice and plan to work in the construction industry. It requires 26 hours of coursework that follows the program below.

CEE 435-Construction Contracting	3 hr
CEE 531–Construction Cost Engineering	3 hr
CEE 532–Construction Project Engineering	3 hr
CEE 536–Critical Path Methods	3 hr
CEE 530–Construction Professional Practice	3 hr
CEE 830-CE&M Seminar	1 hr
Graduate-Level Seminar	1 hr
Graduate CE&M Elective	3 hr
Secondary Concentration Electives	6 hr
	26 hr

MEng (CE&M) students select a secondary concentration in an appropriate area outside Construction Engineering and Management, such as another area of Civil and Environmental Engineering, another department in the College of Engineering, the Graduate School of Business Administration, the Graduate Program in Architecture, or others. The MEng (CE&M) graduate-level seminar may be selected from other civil and environmental engineering areas such as structural or geotechnical engineering.

The MEng (CE&M) program can be completed by all students in 8 months of study (Fall and Winter terms).

The **Master of Science in Engineering (Civil Engineering)** is for students who want to specialize in Construction Engineering and Management, but specifically require their MSE degree to be in civil engineering for reasons such as scholarship sponsor compliance or active-duty military student rules. This degree requires the same coursework as the MSE (CE&M), except that 6 hours of program electives must be outside the construction engineering and management area and 2 hours of graduate-level seminars, one of which should be the CEE 830 CE&M Seminar.

The academic year for all Master's programs consists of the Fall Term (September- December) and the Winter Term (January-April). A limited number of courses may be taught in the Spring Term (May-June). All course selections for all programs must be approved by the student's academic advisor and the TCMP Program Advisor at the beginning of each term of study.

The grading system used for graduate studies follows the following 4-point scale: [A+ = 4.3; A = 4; A- = 3.7; B+ = 3.3; B = 3.0; B- = 2.7; C+ = 2.3; C = 2; C- = 1.7]. A minimum cumulative graduate grade point average (GPA) of 3 on this 4-point scale is required for all graduate courses taken for credit and applied toward a Master's Degree.

ADMISSION REQUIREMENTS

Regular admission to the MSE (CE&M) and MEng (CE&M) programs may be granted to graduates in any recognized branch of engineering. Students with undergraduate degrees in fields related to Civil Engineering, such as Construction Management and Architecture are also eligible for admission but may be required to complete specific background courses in civil engineering without graduate credit. Admission to the MSE (Civil Engineering) program is open to applicants with a Bachelor's degree in Civil Engineering or its substantial equivalent. The Graduate Record Exam (GRE) is recommended for admission to the MEng (CE&M) program and is required for admission to the MSE (CE&M) program.

Applicants with Bachelor's degrees in Architecture or other non-engineering programs may be admitted to the graduate program if they have completed adequate coursework in college-level mathematics (e.g., MATH215 - Multivariable Calculus, MATH 216 - Differential Equations, CEE 373 - Probability and Statistical Methods) and physics (e.g., PHY140 – Mechanics, PHY240 - Electricity and Magnetism) and if they have at least a B average in their mathematics and physics courses. In addition, such applicants, if admitted, will be required to take (without graduate credit, and with a B average) certain basic undergraduate civil engineering courses that are found missing in their background. The courses will include some or all of the following four: CEE 312 Structural Engineering; CEE 351 Civil Engineering Materials; CEE 345 Geotechnical Engineering; and CEE 331 Construction Management.

Most students who have an undergraduate degree in Construction Management will have taken the equivalent of CEE 312, CEE 351, CEE 345, and CEE 331. Most students who have an undergraduate degree in Architecture will have taken the equivalent of CEE 312 and CEE 351. With proper planning, CEE 331 and CEE 345 can be included in University of Michigan B Arch and M Arch programs. Students should work with their academic advisor to ensure that they have taken all classes to satisfy the degree requirements.

DUAL MASTER'S DEGREE PROGRAMS

The Tishman Construction Management Program has formal dual degree programs with the College of Architecture and Urban Planning and the Graduate School of Business Administration through which a student can earn the MEng (CE&M) and the Master of Architecture or the Master of Business Administration. Dual degree programs can also combine the MEng (CE&M) or MSE (CE&M) with Master's in structures, materials, geotechnical, industrial and operations engineering, and naval architecture and marine engineering. Students complete course requirements for both degrees; however, dual counting of some courses reduces the total hours to below that required when pursuing the degrees separately.

For each dual degree program, prospective students must apply to, meet all admission requirements for, and be accepted independently into both programs. Students enrolled in any of the individual programs may apply for admission to a dual program, but they can save time and unnecessary coursework by planning both programs in advance. These dual programs provide unique opportunities to gain the knowledge and credentials of two related programs, each of which is recognized to be among the strongest in the United States.

Master of Architecture. The dual degree program combines the two-year 60-hour M Arch program with the one-year, 26-hour MEng (CE&M) program, resulting in a two and one-half year, approximately 75-hour program.

Master of Business Administration. The dual degree program combines the two-year, 60-hour MBA program with the one-year, 26-hour MEng (CE&M) program, resulting in a two-year (including Spring and/or Summer terms) approximately 69-hour program. The dual degree program can be completed in two years if the first year is devoted to core MBA courses.

Master of Science in Engineering. Dual MEng and MSE degree programs combine a 26-hour MEng (CE&M) or a 30-hour MSE (CE&M) program with another 30-hour Master's program resulting in a 51- hour program, 9 hours of which satisfy requirements for both programs. Usually, these 9 hours are core courses from the other Master's program, used as electives in the Construction Engineering and Management program. An applicant who has recently received or is working toward a Master's degree in another area of engineering can complete the MEng (CE&M) or MSE (CE&M) with an additional 21 hours of coursework.

PhD DEGREE PROGRAM

The Ph.D. program in Civil Engineering (specializing in Construction Engineering and Management) is open to outstanding applicants who have demonstrated excellence in their coursework and a capability for independent research. The focus of the doctoral work is on the student's dissertation research, which must make a significant contribution to knowledge. All admitted Ph.D. students are offered full financial support for the entire duration of their program. Direct admission to the Ph.D. program without a Master's degree is highly competitive and rare. Many applicants who are admissible to a Master's program will be declined for the Ph.D. program if they apply directly.

Ongoing and recent research by TCMP faculty and students has included the following topics:

Dynamic Project Management

The Dynamic Project Management (DPM) group aims at understanding and managing the construction dynamics in large-scale construction projects. Particularly, DPM strives to support diverse decision-making processes in order to manage schedule, cost, and quality as well as sustainability and safety using emerging technologies. DPM also has a great interest in how the decisions made can affect people's behavior and ultimately, would like to incorporate it to support the decision-making processes. To this end, DPM uses computer simulation (System Dynamics, Discrete Event Simulation, and Agent-based Modeling), automatic data capture and tracking technologies (computer vision, wireless sensor network, RFID equivalent technologies, and emission sensor), and visualization techniques. For more information, please visit http://dpm.engin.umich.edu/ or contact Professor SangHyun Lee at shdpm@umich.edu.

Sustainable and Intelligent Civil Infrastructure Systems

Current research in the Sustainable and Intelligent Civil Infrastructure Systems Laboratory (SICIS) is broadly focused on developing simulation models and quantitative tools to understand human impacts, evaluate risks, and assess environmental and social impacts during various life cycle phases of buildings and civil infrastructure systems. The research team uses analytics, simulation (high level architecture, agent-based modeling, system dynamics), financial engineering principles and theories from social sciences to achieve the research objectives. For more information, please visit https://sites.google.com/a/umich.edu/sicislab/ or contact Professor Carol Menassa at menassa@umich.edu.

Laboratory for Interactive Visualization in Engineering

The Laboratory for Interactive Visualization in Engineering (LIVE) conducts research focused on Automation and Robotics, and its applications in the construction, operation, and maintenance of civil infrastructure systems. LIVE is also conducting research in Real-Time Visualization and its applications in construction process monitoring and control. The LIVE also has significant expertise and experience in visual simulation, virtual and augmented reality, indoor and outdoor positioning systems, mobile computing, and its applications in construction and other engineering domains. The LIVE conducts research with full-size Kuka robotic arms and mobile platforms, and other pieces of computing, positioning, and reality-capture hardware. For more information, please visit http://live.engin.umich.edu or contact Professor Vineet Kamat at vkamat@umich.edu.

CIVIL ENGINEERING (CE&M) COURSES

CEE 331 is 4 credit hours. CEE 538 is 2 credit hours. CEE830 is 1 credit hour. All other courses are 3 credit hours. All courses except CEE 331 may be used for graduate credit by graduate students.

CEE 331–Construction Management
Construction contracting for contractors, architects, owners. (1) Organization and administration; industry structure; construction contracts; bonds, insurance. (2) Planning, estimating, and control; quantity takeoff and pricing; labor and equipment estimates; estimating excavation and concrete; proposal preparation; scheduling; accounting and control. Students use contract documents to prepare detailed estimate.

CEE 435– Building Information Modeling
Fundamentals of Building Information Modeling (BIM) methods and their significance in project management and collaboration; Application of BIM in primary construction management functions such as coordination, design clash detection, sequencing, safety, logistics, and communication; BIM-based Integrated Project Delivery (IPD) approach and the project lifecycle; Reality capture methods for as-built documentation in BIM; BIM in facility and asset management; BIM standards and interoperability.

CEE 501-930-Construction Industry Institute Best Practices
Introduction to the Construction Industry Institute (CII) Best Practices defined and developed by CII over the last 25 years. Current professional and practice issues in the construction industry. The course covers the majority of CII Best Practices, such as Front-End Planning, Zero Accident Techniques, Constructability and Materials Management. Lectures focus on Best Practices or practice, and critical issues facing the construction industry.

CEE 530–Construction Professional Practice
Capstone project in construction professional practice. Student teams investigate construction technologies and work with construction industry clients as volunteer consultants to address industry, organization, and project problems. Teams prepare and present written and oral reports weekly. A professional report and video is compiled by the end of the class for presentation to clients. Faculty and industry speakers discuss current technologies and elements for professional success and leadership.

CEE 531–Construction Cost Engineering
Cost engineering for construction organizations, projects, and operations. Construction financing; break even, profit, and cash flow analyses; capital budgeting. Equipment cost and procurement decisions. Construction financial accounting, cost accounting, cost control systems, data bases. Cost indices, parametric estimates, unit price proposals, measuring work and settling claims.

CEE 532–Construction Project Engineering
The course covers the fundamentals of project-based organization, project delivery systems, resource management focusing primarily on human aspects, organizational behavior and culture, change and interface management, productivity measurement and analysis, and construction safety and ergonomics. Examples and case studies from construction are used to help students' learning.

THE UNIVERSITY OF MICHIGAN – TISHMAN CONSTRUCTION MANAGEMENT PROGRAM

CEE 533-Engineering Process Modeling and Risk Analysis
Engineering complex systems, models and simulation. Probabilistic aspects of simulations. Data collection and selection of input distributions. Design of experiments, input and output analysis and interpretation. Random number generators, variate and process generation. Monte Carlo simulation models. Activity cycle diagrams. Cyclone-EZStrobe-Stroboscope networks. Variance reduction techniques, antithetic sampling, common random numbers. Parametric analysis. Single system output analysis and multiple system comparison. Applications from on-site construction, off-site manufacturing, tunneling, earthmoving, mining, land, air, and marine transportation systems.

CEE 534–Construction Engineering, Equipment, and Methods
This course focuses on the construction means, methods, and equipment used to transform a particular design concept into a completed usable structure or facility, with particular focus on the heavy civil engineering construction industry. Emphasis is placed on the selection and optimization of individual items of equipment as well as the systems needed to produce completed work to the required quality on time and on budget.

CEE 536–Critical Path Methods
Construction project planning, scheduling, and control, using activity-on-arrow, activity-on-node, and overlapping network models. Start, finish, float, critical path calculations. Probabilistic activity durations, PERT concepts, merge event bias. Time-cost tradeoff resource allocation and leveling algorithms, cost-schedule integration, computerized control systems. Case studies, term project.

CEE 538– Computer-aided Project Management
Introduction to the application of modern project management computer systems, including Primavera P6 Professional and Microsoft Project, for construction project planning, scheduling and control. This course must be accompanied or preceded by CEE 536 (or MFG 536).

CEE 555–Sustainability of Civil Infrastructure Systems
Life Cycle Cost Analysis and Life Cycle Analysis - Methods and Applications in Buildings; Building Energy Modeling and Simulation; Energy Management in Buildings; Impact of Building Occupants and Behavioral Challenges; Renewable Energy and Efficiency in Buildings; Existing Buildings and Technical/Social Challenges of Energy Retrofits; and Building Certifications (e.g., LEED).

CEE 630–Directed Studies in Construction Engineering
Independent research under the direction of TCMP faculty leading to a written report (3 hr credit) or a Master's Thesis (6 hr credit), and an oral presentation.

CEE 631–Construction Decisions Under Uncertainty
Construction project and organization decisions for the uncertain future. Selection of construction methods, equipment, contract, markup, and financing alternatives having the highest expected values. Uses decision theory, competitive bid analysis, probabilistic modeling and simulation, and multiple regression analysis in managing construction.

CEE 830-Construction Engineering and Management Seminar
Weekly guest speakers discuss CE&M careers and current topics on CE&M professional practice and research.

CEE 990–Dissertation/Pre-Candidate
Election for dissertation work by a doctoral student not yet admitted to status as Candidate.

CEE 995–Dissertation/Candidate
Election for dissertation work by a doctoral student who has been admitted to status as Candidate.

GRADUATE CE&M FACULTY

Photios G. Ioannou (Professor, PhD 1984, Massachusetts Institute of Technology), computerized decision support systems, project and process simulation, project scheduling and control, building construction, design-construction integration, financial management, tunneling.

Vineet R. Kamat (Professor, PhD 2003, Virginia Polytechnic Institute and State University), Automation and robotics, and its applications in the construction, operation, and maintenance of civil infrastructure systems; Real-time visualization and its applications in construction process monitoring and control; 3D visualization of construction processes and products.

SangHyun Lee (Professor, PhD 2006, Massachusetts Institute of Technology), Understanding and management of construction dynamics through the design and development of mechanisms, models, and systems that integrate automatic data acquisition, computer simulation, and visualization, particularly in mega construction projects.

Carol C. Menassa (Associate Professor, PhD 2009, University of Illinois at Urbana Champaign), Sustainable civil infrastructure systems; understanding and modeling the impact of occupants on energy use in buildings and developing decision frameworks to assist in building operations and management as well as, sustainable retrofit decisions.

ADDITIONAL INFORMATION

Send inquiries to Ms. Anne Speigle (Graduate Admissions Coordinator) at aspeigle@umich.edu or to Professor Vineet R. Kamat (Program Advisor) at vkamat@umich.edu. Mailing Address: Department of Civil and Environmental Engineering, 2105 G.G. Brown Building, University of Michigan, Ann Arbor, MI 48109-2125. Phone: (734) 764-4325. Fax: (734) 764-4292. Access additional information at http://tcmp.engin.umich.edu.

[Last updated by Professor Vineet R. Kamat on 09/13/2021]

University of Michigan
College of Engineering
EECS Department
2417-E EECS
1301 Beal Ave.
Ann Arbor, MI 48109

To: The College of Engineering Curriculum Committee
From: Robert Dick
Chair of the Computer Engineering (B.S.E.) Program Committee
Date: 25 February 2024

Subject

Permitting linear algebra as an option to partially satisfy the math requirements of the Computer Engineering program.

Proposed Change

Computer Engineering students will be permitted to satisfy one of their CoE mathematics course requirements with either Multivariable & Vector Calculus or Linear Algebra.

Currently, one of the CoE mathematics course requirements must be satisfied with Multivariable & Vector Calculus.

The following courses will be permitted in lieu of Math 215: MATH 214, 217, 417 or 419.

The CE program is already less flexible than either of its sister programs (Electrical Engineering and Computer Science). Permitting students to take Linear Algebra in lieu of Multivariable & Vector Calculus is preferable to adding another requirement.

Desired Date of Effect

As soon as practical. Fall 2024 would be ideal, but Winter 2025 is also fine. Please follow your normal processes and select the earliest semester that remains practical if and when the change is approved.

Plans to Transition Current Students to Change

The change strictly increases flexibility so current students would not be required to make any changes to their plans. If approved, the new option would be available to both current and incoming students.

Attached, please find an example schedule that would be provided as a reference to students should the requested changes be approved. Changes from the current example schedule in the Computer Engineering Program Guide are marked in red. The only change requiring explanation is moving the suggested semester for Linear Algebra or Multivariable & Vector Calculus one semester earlier to enable prerequisites to popular upper-level courses to be satisfied earlier, and moving the recommended semester for Math 216 one semester later to more evenly distribute heavy-workload engineering courses over time.

Benefits

Based on a survey of their teachers, Linear Algebra is more useful in upper-level CE courses than Multivariable & Vector Calculus for the following courses EECS 442, EECS 452, EECS 461,

EECS 467, EECS 483, and EECS 507. The survey results did not indicate that Multivariable & Vector Calculus is more useful than Linear Algebra for any upper-level CE course. Linear Algebra is a prerequisite for EECS 467 and EECS 442. The CE Program Committee unanimously found Linear Algebra to be more useful to CEs than Multivariable & Vector Calculus.

Disadvantages

Encouraging first-year (nascent) CE students to take Linear Algebra instead of Multivariable & Vector Calculus might make it harder for them to transfer to the Electrical Engineering (EE) program. However, students in this situation are permitted to immediately transfer to EE and take Multivariable & Vector Calculus at any time before graduating. An estimated 0.67 students per year transfer from CE to EE and need to take Multivariable & Vector Calculus in addition to (already-taken) Linear Algebra. Many of these would have taken Linear Algebra anyway due to prerequisites of some EE courses.

The change may increase the enrollment in Linear Algebra courses. When the changes of this nature and scale were discussed with the Department of Mathematics by the College of Engineering Math Curriculum Review Committee, the Department of Mathematics representatives did not oppose the change. If the change is approved, the CE Program Committee will inform the Department of Mathematics.

Supporting Parties

The CE Program Committee unanimously approved permitting Linear Algebra in lieu of Multivariable & Vector Calculus.

The ECE Division and CSE Division of the EECS Department each approved the change.

The change is consistent with the recommendations and findings of the College of Engineering Math Curriculum Review Committee, which can be found at the following clickable URL: https://docs.google.com/document/d/1JZrv_7Cl59dI0YM3RvMFGIcTZxpCn-XjwhJJh7O2caw . In particular, it is aligned with Recommendation 2.d on page 6 of the report.

ABET Implications

The ABET Program Criteria for "Electrical, Computer, Communications, Telecommunication(s) and Similarly Named Engineering Programs" do not contain Multivariable & Vector Calculus. Linear Algebra is in the ABET list of "College-Level Mathemathcs" examples.

Sincerely,

Robert Dick, Ph.D.
Chair of the Computer Engineering Program Committee
University of Michigan
http://robertdick.org/
734–763–3329

		Semester							
	Credits	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CoE Common Core (55 credits)									
MATH 115, 116, and 216	12	4	4		**deleted**	**4**			
Math 214, 215, **217**, **417**, **or 419**	4				**4**	**deleted**			
ENGR 100	4		4						
ENGR 101	4	4							
CHEM 125/126/130	5		5						
PHYSICS 140/141; PHYSICS 240/241	10	5		5					
Intellectual Breadth	16	4	4		4		4		
CE Program Subjects (32 credits)									
EECS 203: Discrete Math	4			4					
EECS 215: Introduction to Circuits	4				4				
EECS 216: Signals and Systems	4					4			
EECS 270: Introduction to Logic Design	4			4					
EECS 280: Programming and Introductory Data Structures	4				4				
EECS 370: Introduction to Computer Organization	4					4			
EECS 301 (4 cr), MATH 425 (3 cr) or STATS 412 (3 cr)	3-4						3-4		
EECS 496: Major Design Professionalism or ENGR 499-002	2								2
TCHNCLCM 300: Technical Communication for EECS	1					1			
TCHNCLCM 496: Advanced Technical Comm. for ECE	2								2
General and Technical Electives (41 credits)									
Core Electives	8						8		
Upper Level CE Electives (MDE)	10							4	6
EECS Electives	3							3	
Flexible Technical Electives	7							5	2
General Electives	13			3		3		4	3
TOTAL	**128**	**17**	**17**	**16**	**16**	**16**	**15**	**16**	**15**

Questions for the CCC for Fall 2022 Courses

(EECS 587 is a 4 credit course with 3 credits for LEC and 1 credit for Lab. The class was scheduled during Fall 2022 with 3 hours per week for LEC and 1 hour per week for Lab. The Lab section met weekly for one hour per week instead of the two hours required for sections 011-012.)

Question/comment from EECS Department regarding EECS 587:

There are 300 (*minutes of*) office hours in addition to the class and discussion section hours (the 240), plus there is significant use of Piazza. I.e., they can interact with GSIs and the professor more than 540 hours per week. That's not counting the time the students spend on the computers (the equipment is the computer). On average they spend more time on the computer and in class than people in lab courses spend in the lab.

For CCC Member Discussion:

1. Should use of Piazza and office hours factor into contact hours? If so, how would these elements be reflected in the CoE Policy for the Assignment of Credit Hours?

CCC Review and Approval of Declaration/Common Requirements Changes

There is a gray area regarding common requirement substitutions and changes to declaration requirements regarding whether it should come before the CCC for review and approval. Program changes need to go before the CCC (and later the faculty) for quality control, i.e., to make sure that a high standard is being maintained across the College, as well as to catch any unintended consequences.

There is precedence for this: In 2003, In Article VII. College Committees, VII.B.I The Curriculum Committee, under Purpose, states, "The Curriculum Committee shall examine all educational programs of the College, graduate and undergraduate, and all proposed changes, and encourage full discussion of the proposals by the members before they take action. The Committee, moreover, shall initiate changes by asking departments to reexamine their programs or specific course offerings. Program Committees shall administer by the departments or the degree programs. The Curriculum Committee advises, suggests, coordinates, stimulates, and in general acts for the best interest of the College. *Its recommendations regarding changes in programs, college-wide curriculum requirements, and changes in classes used in the program requirements of more than one department shall be brought before the faculty for approval. The Committee will have the authority to approve by a 2/3 vote all other curriculum-related change without a vote of the faculty."*

Per Fred Terry, previous CCC Chair, "All of the changes in the CoE core requirements require approval by the CoE Curriculum Committee (CoE Faculty Rules, VII.B. paragraph 2). By long tradition in the CoE Curriculum Committee, major changes of this type are brought to the CoE Faculty Meeting for a vote. This procedure was carefully followed during the controversial creation of Math 214 in place of Math 216. This change in the old CoE common core was guided by James Holloway when he was ADUE."

PROPOSAL:

1. **CCC vote whether to be the approving body for the Declaration Requirements (then proceeds to Faculty Committee vote)**
2. **CCC vote whether to be the approving body for the Common Requirements (then proceeds to Faculty Committee vote)**

The current federal definition of a credit hour (34 CFR 600.2) states: for each credit earned, students must engage in a minimum of one hour of faculty-led instruction or academic engagement and at least an additional two hours of work outside of class each week for approximately 15 weeks. It also states that an equivalent amount of academic engagement is required on the part of the student who participates in other academic activities for which the institution awards credit hours. These activities could include independent studies, internships, experiential learning, or similar activities that are integrated into the formal curricula of a school or college. Hybrid and online courses require an equivalent amount of instruction and student work as required by in-person courses.

Office of the provost guidance:

Faculty and instructors — with oversight and input from faculty-led curriculum committees — should determine the activities that would appropriately be viewed as faculty-led engagement within the context of a course and academic program.

Current LSA credit hour policy:

Course credit is based on contact hours (time spent in class with the instructor) for all LSA courses. This means one contact hour per credit for Lectures, Discussions, Recitations, and Seminars. Students do not get credit for homework, field trips, film screenings, or reading and writing assignments. For each credit earned, students are expected to spend in three hours of work each week outside of class. The same rule also applies to Experiential and Independent Study courses.

Labs that meet in an actual laboratory classroom such as used in Biology and Chemistry must meet for at least two hours for each credit earned. When departments schedule a “lab” for the purpose of film screenings, for example, this is just a scheduling tool to ensure students set aside that time for required class activity. In this case the instructor need not be present and therefore this time is not considered a part of contact hours for the course.

In the case of Discussions, students are spending time with the instructor (or GSI) to deal with more complex or detailed course content. This is considered a part of contact hours, so students earn one credit for each hour of discussion.

Ross School of Business:

……

Independent Study: Definition Students receive substantial individual consultation and guidance from the instructor. Total student effort should be comparable to that involved in lecture or seminar courses to justify the credit allocated to the Independent Study. Number of contact hours per week Substantial contact between instructor and student is required, but not necessarily on a weekly basis.

Architecture and Urban Planning

Independent Study Definition: Students receive individual consultation and guidance from the instructor. Total student effort should be comparable to that involved in lecture or seminar courses. Number of contact hours per week Contact between instructor and student is required, but not necessarily on a weekly basis

Education School:

…….

Hybrid and fully remote courses require an equivalent amount of

instructor contact hours.

School of Kinesiology:

……..

Exceptions shall be granted on a course-by-course basis and under truly special circumstances, at the program level. A program may appeal for an exception to the policy by contacting the Associate Dean for Undergraduate Affairs who will direct the appeal to the CIC and EC.

Rackham:

Current CoE credit hour policy:

Course credit is based on contact hours (time spent by students engaged with the course instructor) for all Engineering courses. This means one contact hour per credit hour in a week for Lectures, Discussions, and Recitations.

For each credit earned per full academic term, students are expected to receive at least one contact hour of instruction and perform at least two to three hours of work outside of class each week.

Independent Study, Special Topics, Experiential and Seminar courses have the same total engagement requirements (contact hours plus hours of additional work) as listed above with the understanding that engagement may not be scheduled on a weekly basis as determined at the department level.

Laboratory sections are expected to meet for at least two hours for each credit earned. A laboratory section should be set up as the meet in an actual laboratory classroom if the laboratory work involves in-person operation of equipment under oversight of instructors. A laboratory section can be set up as the meet in a virtual or remote laboratory classroom if the laboratory work only involves software development or operation of non-critical hardware, and an equivalent amount of instruction as required by in-person laboratory sections is provided.

Hybrid and Online courses require an equivalent amount of instruction and student work as required by in-person courses. The online, self-paced, or asynchronous learning modules in such courses can be counted as contact hours if these modules are prepared by the instructors and an equivalent amount of instructor-led instruction as required by in-person lecture sections is provided.

Courses that do not fall within any of the aforementioned categories will be treated individually. The course description must justify the conditions for credit. The CoE Curriculum Committee must approve the credit hour to contact hour ratio for such courses.

1210 LSA Building
500 S. State Street
Ann Arbor, MI 48109-1382
Phone: 734.763.2113
Fax: 734.936.3148

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-01-30
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 212	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 212
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Solid and Structural Mechanics	Course Title (full title) Solid and Structural Mechanics
☐	Abbreviated Title (20 char) Solid&Struct Mech	Abbreviated Title (20 char) Solid&Struct Mech
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Fundamental principles of solid and structural mechanics and their application in engineering disciplines. Covered: concepts of stress and strain, stress and strain transformations, axial, torsion, bending, and combined loading, and elastic deformations.	
☐	Full Term Credit Hours Undergraduate Min: 3 Graduate Min: Undergraduate Max: 3 Graduate Max:	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Civil & Environmental Engin Catalog: 212

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☑	Advisory Prerequisite (254 char) CEE 211 or equivalent.	Advisory Prerequisite (254 char)
☑	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) CEE 211 or equivalent Minimum grade requirement: C-
☐	Credit Exclusions No credit granted to those who have completed or are enrolled in MECHENG 211.	Credit Exclusions No credit granted to those who have completed or are enrolled in MECHENG 211.

☐	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☑ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Enrica Bernardini Cognizant Faculty Member Title: Lecturer IV

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Lynn Shock Email: lshock@umich.edu Phone: 734-647-4106

CoE Curriculum Committee Representative: Radoslaw L. Michalowski Print: Radoslaw L. Michalowski Date: 3/1/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Print: Yafeng Yin Date: 3/4/2024

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description Fundamental principles of solid and structural mechanics and their application in engineering disciplines. Covered: concepts of stress and strain, stress and strain transformations, axial, torsion, bending, and combined loading, and elastic deformations.	Course Description Fundamental principles of solid and structural mechanics and their application in engineering disciplines. Covered: concepts of stress and strain, stress and strain transformations, axial, torsion, bending, and combined loading, and elastic deformations.
Class Length Full term	Class Length
Contact hours (lecture): 3	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
This course is part of the BSE in Civil Engineering curriculum “Required Program Subjects”. As such, it is required for all students majoring in Civil Engineering. It is an advisory prerequisite for several of the “Program Electives”.

Special resources of facilities required for this course:
None

Supporting statement:

Adding CEE 211 - Statics and Dynamics as an enforced, rather than advisory, prerequisite is requested as CEE 212 builds substantially on the material that students learn in CEE 211. Students taking this course without having previously completed CEE 211 do not have the tools to grasp the fundamental concepts and succeed in this course.

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☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission:
Effective Term: Winter 2025

	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 365	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 365
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Environmental Engineering Principles	Course Title (full title) Environmental Engineering Principles
☐	Abbreviated Title (20 char) Env Engr Principles	Abbreviated Title (20 char) Env Engr Principles
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) An introduction to mass balance modeling of contaminant fate, transport and removal in the environment; commonly used reactor configurations for water and air quality control; partitioning of contaminant types and sources; regional and global contemporary environmental issues.	
☐	Full Term Credit Hours Undergraduate Min: 4 Graduate Min: Undergraduate Max:4 Graduate Max:	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Students	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Civil & Environmental Engin Catalog: 365

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☐	Advisory Prerequisite (254 char) CHEM 130, MATH 116	Advisory Prerequisite (254 char) CHEM 130, MATH 116
☑	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) CEE 265 Minimum grade requirement: C-
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☑ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☑ Fall ☐ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Jeremy Semrau Cognizant Faculty Member Title: Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Lynn Shock Email: lshock@umich.edu Phone: 734.764.4106

CoE Curriculum Committee Representative:	Radoslaw L. Michalowski	Radoslaw L. Michalowski	3/1/2024
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Yafeng Yin	Date: 3/4/2024
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description An introduction to mass balance modeling of contaminant fate, transport and removal in the environment; commonly used reactor configurations for water and air quality control; partitioning of contaminants among environmental media; contaminant types and sources; regional and global contemporary environmental issues.	Course Description An introduction to mass balance modeling of contaminant fate, transport and removal in the environment; commonly used reactor configurations for water and air quality control; partitioning of contaminant types and sources; regional and global contemporary environmental issues.
Class Length Full term	Class Length Full term
Contact hours (lecture): **3**	Contact hours (lecture): **3**
Contact hours (recitation) 1	Contact hours (recitation) 1
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Key course in environmental engineering undergraduate curriculum, required for all Env Eng BSE students.

Special resources of facilities required for this course:
None

Supporting statement:
The change is requested to ensure students have adequate preparation to succeed in CEE 365, i.e., CEE 265 is a critical pre-requisite.

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500 S. State Street
Ann Arbor, MI 48109-1382
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Fax: 734.936.3148

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission:
Effective Term: Winter 2025

☐	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 450	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 450
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐		
☐	Course Title (full title) Introduction to Transportation Engineering	Course Title (full title) Introduction to Transportation Engineering
☐	Abbreviated Title (20 char) Intro Transp Engr	Abbreviated Title (20 char) Intro Transp Engr
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Fundamentals of planning, design, and operation of transportation infrastructure. Topics covered include driver and vehicle performance characteristics, roadway design principles, multimodal system design, traffic flow modeling and traffic operations analysis, transportation planning and forecasting, and the impacts of emerging technologies (e.g., connected and automated vehicle) on transportation infrastructure.	
☐	Full Term Credit Hours Undergraduate Min: 4 Graduate Min: 4 Undergraduate Max: 4 Graduate Max: 4	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Civil & Environmental Engin Catalog: 450

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☐	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char)
☑	Enforced Prerequisite (254 char) (Math 215 and Physics 240 with a minimum grade of C or better) or graduate standing. Minimum grade requirement: C	Enforced Prerequisite (254 char) Math 215 and CEE 373 (non-CEE undergraduate statistics classes acceptable) with a grade of C or better, or graduate standing. Minimum grade requirement: C
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☐ Seminar ☑ Recitation ☐ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☐ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Atiyya Shaw Cognizant Faculty Member Title : Assistant Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Lynn Shock Email: lshock@umich.edu Phone: 734.764.4106

CoE Curriculum Committee Representative:	Radoslaw L. Michalowski	Radoslaw L. Michalowski	3/1/2024
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Yafeng Yin	Date: 3/4/2024
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description Fundamentals of planning, design, and operation of highway transportation facilities. Topics covered include driver and vehicle performance characteristics, highway geometric design principles, basics of traffic analysis, traffic signal operations, transportation planning, connected and automated vehicle technologies and their impacts to the transportation infrastructure.	Course Description Fundamentals of planning, design, and operation of transportation infrastructure. Topics covered include driver and vehicle performance characteristics, roadway design principles, multimodal system design, traffic flow modeling and traffic operations analysis, transportation planning and forecasting, and the impacts of emerging technologies (e.g., connected and automated vehicle) on transportation infrastructure.
Class Length Full term	Class Length Full term
Contact hours (lecture): 4	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation) 1
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:

- **The prerequisites for CEE 450 have been adjusted to remove Phys 240.** According to its course description, Physics 240 covers: "charge, Coulomb's law, electric fields, Gauss' law, electric potential, capacitors and dielectrics, current and resistance, EMF and circuits, magnetic fields, Biot-Savart law, Amperes law, Faraday's Law of Induction, simple AC circuits, and electromagnetic waves." Currently, CEE 450's topics are as follows, and do not rely on any contents in Phys 240:
  - *Overview of transportation systems*
  - *Transportation system users*
  - *Transportation vehicles and vehicle characteristics*

- *Transportation infrastructure and systems*
  - *Roadway design*
    - *Vertical curves*
    - *Horizontal curves*
    - *Superelevation*
    - *Traffic operations*
  - *Active transportation design*
  - *Mass transit systems*
- *Transportation planning and forecasting*
- *New and emerging technologies in transportation*

- **The prerequisites for CEE 450 have been adjusted to add CEE 373**. All past and current instructors (Henry Liu, Neda Masoud, and Atiyya Shaw) agree that understanding of probabilities and distributions is important foundational knowledge for the travel flow modeling unit in CEE 450.

- **The course description for CEE 450 has had minor updates to include some additional content**. This additional content provides students with additional breadth beyond roadway/motor vehicle-related topics and infrastructure. This content is not only increasingly of interest to segments of students, but is important to consider for a user-centric, sustainable, and equitable transportation system.

- The course hours are changed from four lecture hours to 3 lecture hours + 1 recitation hour. The latter is how the course is being taught and has been offered. This is a correction, not a change.

- **The cognizant faculty member for CEE 450 has been changed from Henry Liu to Atiyya Shaw**. Atiyya will be responsible for teaching this course on a regular basis.

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-01-30
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 521	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 521
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☑	Course Title (full title) Flow Open Channels	Course Title (full title) Flow in Open Channels
☐	Abbreviated Title (20 char) Flow Open Channels	Abbreviated Title (20 char) Flow Open Channels
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Conservation laws for transient flow in open channels; shallow-water approximation; the method of characteristics; simple waves and hydraulic jumps; non-reflective boundary conditions; dam-break analysis; overland flow; prediction and mitigation of flood waves.	
☐	Full Term Credit Hours Undergraduate Min: 3 Graduate Min: 3 Undergraduate Max: 3 Graduate Max: 3	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits: 3	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Civil & Environmental Engin Catalog: 521

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☑	Advisory Prerequisite (254 char) CEE 325 or equivalent	Advisory Prerequisite (254 char) CEE 325 or equivalent, and CEE 421
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☑ Fall ☐ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Lissa MacVean Cognizant Faculty Member Title:Lecturer V

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Lynn Shock Email: lshock@umich.edu Phone: 734-764-4106

CoE Curriculum Committee Representative:	Radoslaw L. Michalowski	Print: Radoslaw L. Michalowski	Date: 3/1/2024
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Yafeng Yin	Date: 3/4/2024
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description Conservation laws for transient flow in open channels; shallow-water approximation; the method of characteristics; simple waves and hydraulic jumps; non-reflective boundary conditions; dam-break analysis; overland flow; prediction and mitigation of flood waves.	Course Description Conservation laws for transient flow in open channels; shallow-water approximation; the method of characteristics; simple waves and hydraulic jumps; non-reflective boundary conditions; dam-break analysis; overland flow; prediction and mitigation of flood waves.
Class Length Full term	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): 3
Contact hours (recitation) 3	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Other

Special resources of facilities required for this course:

Supporting statement:
1. Adding CEE 421 as advisory pre-requisite: CEE 521 builds upon the content in CEE 421 related to channel hydraulics and overland flow, and students struggle with CEE 521 if it is their first exposure to these concepts
2. The course is being changed from “Recitation” to “Lecture” to accurately reflect the course format.

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Fax: 734.936.3148

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-09
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 537	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 537
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Construction of Buildings	Course Title (full title) Construction of Buildings
☐	Abbreviated Title (20 char) Building Construct	Abbreviated Title (20 char) Building Construct
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Material selection, construction details, manufacture, fabrication, and erection of building structures using steel, light wood, timber, cast-in-place concrete, precast concrete, and masonry; and materials for roof, floor, and wall surfaces. Zoning, building codes, and other legal issues. Introduction to HVAC and electrical systems. Field trips to construction sites.	
☐	Full Term Credit Hours Undergraduate Min: 3 Graduate Min: 3 Undergraduate Max: 3 Graduate Max: 3	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☑	Course Credit Type Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Civil & Environmental Engin Catalog: 537

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☑	Advisory Prerequisite (254 char) CEE 315	Advisory Prerequisite (254 char) Graduate standing, or CEE 331 and CEE 351
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☐ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: David Kelly Cognizant Faculty Member Title: Lecture III

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Lynn Shock Email: lshock@umich.edu Phone: 734-647-4106

CoE Curriculum Committee Representative:	Radoslaw L. Michalowski	Radoslaw L. Michalowski	3/1/2024
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Yafeng Yin	Date: 3/4/2024
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description Material selection, construction details, manufacture, fabrication, and erection of building structures using steel, light wood, timber, cast-in-place concrete, precast concrete, and masonry; and materials for roof, floor, and wall surfaces. Zoning, building codes, and other legal issues. Introduction to HVAC and electrical systems. Field trips to construction sites.	Course Description Material selection, construction details, manufacture, fabrication, and erection of building structures using steel, light wood, timber, cast-in-place concrete, precast concrete, and masonry; and materials for roof, floor, and wall surfaces. Zoning, building codes, and other legal issues. Introduction to HVAC and electrical systems. Field trips to construction sites.
Class Length Full term	Class Length Full term
Contact hours (lecture): 3	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
CEE 537 is an elective course for the MSE and MEng in Constr. Engrg. & Mgmt. as well as the MSE in Civil Engineering (concentration in Constr. Engrg. & Mgmt.). Undergraduate CEE students can also take the course as a Technical Elective.

Special resources of facilities required for this course:

Supporting statement:
This CARF is submitted to: (a) update the advisory prerequisites for undergraduate students; (b) change the term typically offered to Winter; and (c) update the cognizant faculty.

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Phone: 734.763.2113
Fax: 734.936.3148

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested

☐ New Course
☑ Modification of Existing Course
☐ Deletion of Existing Course

Date of Submission: 2023-11-09
Effective Term: Winter 2025

☐	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 575	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 575
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☑	Course Title (full title) Sensing for Civil Infrastructure Systems	Course Title (full title) Sensors, Data, and Automation
☑	Abbreviated Title (20 char) Infrastruct Sensing	Abbreviated Title (20 char) SensorsandData
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Sensors and smart technologies across engineering and science. Fundamentals of sensor physics, demonstrating how to measure and convert physical processes into digital information. Topics include the theories behind leading sensing technologies, data acquisition, and internet-connected devices. Essential aspects of data processing and cloud computing for real-time sensor data. Students will be equipped to select sensors, design wireless networks, send data to the internet, process and analyze real-time data, and automate solutions across various applications.	
☐	Full Term Credit Hours Undergraduate Min: 3 Graduate Min: 3 Undergraduate Max: 3 Graduate Max: 3	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Civil & Environmental Engin Catalog: 575

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☐	Advisory Prerequisite (254 char) Physics 240	Advisory Prerequisite (254 char) Physics 240
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

	Course Components	Graded Component	Terms Typically Offered
☐	☑ Lecture	☑	☐ Fall
	☐ Seminar	☐	☑ Winter
	☐ Recitation	☐	☐ Spring
	☐ Lab	☐	☐ Summer
	☐ Discussion	☐	☐ Spring/Summer
	☐ Independent Study	☐	

Cognizant Faculty Member Name: Branko Kerkez Cognizant Faculty Member Title: Assoc Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Lynn Shock Email: lshock@umich.edu Phone: 734-764-4106

CoE Curriculum Committee Representative:	Radoslaw L. Michalowski	Radoslaw L. Michalowski	3/1/2024
CoE Curriculum Committee Chair:		Print:	Date:
Home Department:		Print: Yafeng Yin	Date: 3/4/2024
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description Sensor technologies for civil infrastructure. Fundamentals of sensor theory, fabrication, operation and deployment. Data acquisition and management methods for large-scale sensor networks. Optimal sensor placement. Data to decision support systems. Physics-based and data-driven interrogation methods for system identification, estimation and control. Case studies of deployments in built and natural environments.	Course Description Sensors and smart technologies across engineering and science. Fundamentals of sensor physics, demonstrating how to measure and convert physical processes into digital information. Topics include the theories behind leading sensing technologies, data acquisition, and internet-connected devices. Essential aspects of data processing and cloud computing for real-time sensor data. Students will be equipped to select sensors, design wireless networks, send data to the internet, process and analyze real-time data, and automate solutions across various applications.
Class Length Full term	Class Length Full term
Contact hours (lecture): 3	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Free Elective

Special resources of facilities required for this course:
None required.

Supporting statement:
The course has evolved to include students from all engineering majors, as well as non-engineers. The original description was very focused on Civil Engineering and infrastructure, and the course has evolved significantly since then. The proposed changes to the title and description more accurately reflect the changes in the topics and diversity of students in the course.

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☑ New Course
- ☐ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-12
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING			**REQUESTED LISTING**		
☑	Dept (Home): Subject: Catalog:			Dept (Home): Climate & Meteorology Subject: CLIMATE Catalog: 746		
	☐ Course is Cross-Listed with Other Departments			☑ Course is Cross-Listed with Other Departments		
☑	Department	Subject	Catalog Number	Department	Subject	Catalog Number
				CLaSP - SPACE - 746		
☑	Course Title (full title)			Course Title (full title) CLaSP PhD Professional Seminar		
☑	Abbreviated Title (20 char)			Abbreviated Title (20 char) PhD Professional Sem		
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Introduction to professional skills which support PhD student success within the CLASP Department. Topics include advisor relationships, student rights, personal finances, scientific communication, project definition and planning, attending conferences, reading journal articles, mentoring others, and code and data management.					
☑	Full Term Credit Hours Undergraduate Min: Undergraduate Max:	Graduate Min: 1 Graduate Max: 1		Half Term Credit Hours Undergraduate Min: Undergraduate Max:	Graduate Min: Graduate Max:	
☑	Course Credit Type Rackham Graduate Student, Non-Rackham Graduate Student					
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:			☐ Course is Y graded ☐ Can be taken more than once in the same term		

Subject: Catalog:

☑	Grading Basis ☐ Graded (A – E) ☐ Credit/No Credit ☑ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	REQUESTED LISTING
☐	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char)
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions
☑	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☐ Discussion ☐ Independent Study Graded Component ☑ ☐ ☐ ☐ ☐ ☐ Terms Typically Offered ☑ Fall ☐ Winter ☐ Spring ☐ Summer ☐ Spring/Summer	

Cognizant Faculty Member Name: Michael Liemohn Cognizant Faculty Member Title: Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Claire Miller Email: ccdewitt@umich.edu Phone:

CoE Curriculum Committee Representative:	Frank J. Marsik	Print:	Frank J. Marsik	Date:	2/14/24
CoE Curriculum Committee Chair:		Print:		Date:	
Home Department Chair:	Gretchen Keppel-Aleks	Print:	Gretchen Keppel-Aleks	Date:	14 Feb 2024
Cross-Listed Department Chair:	Gretchen Keppel-Aleks	Print:	Gretchen Keppel-Aleks	Date:	14 Feb 2024
Cross-Listed Department Chair:		Print:		Date:	
Cross-Listed Department Chair:		Print:		Date:	

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description	Course Description Introduction to professional skills which support PhD student success within the CLASP Department. Topics include advisor relationships, student rights, personal finances, scientific communication, project definition and planning, attending conferences, reading journal articles, mentoring others, and code and data management.
Class Length	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): 1
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Optional but highly recommended for all first-year PhD CLaSP students.

Special resources of facilities required for this course:

Supporting statement:
Through a Rackham Student Ally grant, 4 PhD students were hired to develop the course, during which they brainstormed topics, evaluated the list and chose 14 for a semester-long series, researched content and developed presentation material and resource sheets. The course is typically taught with not only one of the co-instructors but also a senior PhD student present for Q&A.

Syllabus
CLIMATE/SPACE 501-004:
CLaSP PhD Professional Seminar
Fall 2023 (1 Credit)

A course in successfully navigating the first year of CLaSP PhD student life

Course Description:

Successfully navigating a PhD program requires more than academic and research abilities. Mastery of professional and administrative skills are critical to getting the most of your time as a student to prepare for future careers. In this course, we cover a range of 'soft skills' topics that do not fall into an academic discipline but are nevertheless important to ensure successful education. Each class session will feature a lecture or activity on a particular topic, often accompanied by resource sheets. By the end of the course, the student shall gain an understanding of scientific communication venues such as conferences and publications, learn strategies for project identification, management, and reproducibility, and explore strategies for communicating with advisors, mentees, the research community, and the general public.

Course Prerequisites:

Graduate standing.

Instructors:

Dr. Mike Liemohn, Professor, Department of Climate and Space Sciences and Engineering
Room 1420, Climate and Space Research Building (on North Campus, 2455 Hayward St.)
Email: liemohn@umich.edu

Dr. Allison Steiner, Professor, Department of Climate and Space Sciences and Engineering
Room 2517E, Climate and Space Research Building
Email: alsteine@umich.edu

Dr. Jeremy Bassis, Professor, Department of Climate and Space Sciences and Engineering
Room 2529, Climate and Space Research Building
Email: jbassis@umich.edu

Class Sessions:

Wednesdays from 2:30 pm – 3:20 pm, in GG Brown room 2147 (in the Civil and Environmental Engineering wing).

We are also using Lecture Capture and will post the videos after each class session.

Learning Objectives:

It is expected that, by the end of the course, students will be able to:

- Understand what it means to be a PhD student at the University of Michigan
- Know how to read a scientific journal article and, generally, about the publication process
- Be familiar with techniques for optimizing your experiences at science conferences
- Understand the mentor-mentee relationship, from both sides

- Set up a github site and a structure for data set management

Grading Apportionment:

This is a 1-credit class. Not much beyond attending class sessions is expected of you. Your overall course grade is made of several elements:

In-class participation	70%	Weekly
Professional Development Activity	10%	One extra seminar/workshop
After-class assignments	20%	There will be two, so 10% each

I hope that you all get 100% in this class.

In-Class Participation:

If you attend and participate, then you get credit for that day. We have 14 class sessions; for full credit on this grading element, you must attend (in person) 12 of them. An excused absence for illness, religious observance, or school-related activities counts as attendance. Less than 12 will result in a proportional drop in your grade for this element (70% / 12 = 5.83% towards the course grade for each unexcused absence beyond two).

Details of Homework and the Professional Development Activity:

There will be two graded-for-completion homework assignments: (1) a draft mentoring plan between you and your advisor and (2) a draft data management plan for how you might handle the data sets for your research. These will be brief (~1 page) written documents, uploaded to Canvas (full grade for completion).

For the professional development activity, please attend one extra seminar or workshop beyond what is required of you (i.e., beyond our class sessions, beyond the RCRS training, and beyond the requirements for other classes, like CLaSP 747/749). This can be a seminar in another department, a CRLT training, or meeting with a visitor to your department. If you need clarification on what is acceptable, then please check with Dr. Liemohn. You will be asked to write a brief statement (< 1/2 page) about the event and upload it to Canvas (full grade for completion).

Additional optional out-of-class activities will be suggested. These are not required and will not be graded but are encouraged for additional skill-building enrichment.

Student Collaboration:

I encourage collaboration and peer tutoring. Please help each other learn and get through the course requirements. Even more so, help each other get through life as U-M PhD students. When it comes to actually writing/typing up a submission, though, I expect each of you to do your own work. You learn very little by copying another's answers.

Course Grade Policy:

Your overall grade in the course will be a satisfactory or unsatisfactory. You need to reach an 80% on the overall course score to receive a satisfactory grade. Yes, if you attend all of the class sessions, then you only need to do one of the three "assignments" to pass. I hope that you do them all, though.

Extra Credit:

There will be one opportunity for extra credit near the end of the course: turning in the receipt acknowledging that you filled out the course evaluation. If you upload a screen shot/pic/PDF of the page showing that you submitted it, then this will count for extra percentage points towards your overall course grade. Specifically, it will replace one unexcused absence (5.83%). This will not be reflected in Canvas but will be added afterwards.

I highly value your feedback about the course and look forward to reading your comments on what went well and what could be done differently. I strive to improve my teaching skills every term. I hope that you submit a course evaluation even if you don't need the extra credit.

Late Policy:

The three assignments turned in via Canvas are all due by 11:59 pm on the last day of class: December 6. I need to be done with this class before the Fall AGU Meeting the next week, so assignments submitted late are reduced by 10% **per day** off the possible score (i.e. 1% towards the total grade). Excused late submissions **must** be requested ***before*** the due date and time. I will be fairly lenient in granting extensions, but please request extensions ahead of time. A sudden injury or illness with doctor's note is about the only excuse I will accept after the due date.

Religious or School-Function-Related Absence

If students expect to miss classes as a consequence of their religious observance or are traveling with a U-M sports team or organization, then alternate arrangements will be made to accommodate missed academic work. It is the obligation of students to provide the instructor with reasonable notice of the dates on which they will be absent (*before* they occur). We will determine a mutually agreeable alternative timeline within the boundaries of the class (usually a shifted deadline).

Disability Access

If you think you may need an accommodation for a disability, then please inform the instructor early in the term. You should contact the Services for Students with Disabilities (SSD) office to be issued a Verified Individual Services Accommodation (VISA) form, to be given to the instructor. I will fully accommodate all such requests.

Student Mental Health and Wellbeing

If you or someone you know if feeling overwhelmed, depressed, and/or in need of support, then services are available. Grad school can be hard, but please know that you are not alone in having such thoughts and feelings, nor do you have to go through it alone. The first option is talking to a trusted friend or relative. This includes me; I am our department's Rackham Diversity Ally and I am ready and willing to listen to your story. For professional help, please contact Counseling and Psychological Services (CAPS) at 734-764-8312 or online at https://caps.umich.edu. You may also consult University Health Service (UHS) at 734-764-8320 and at https://www.uhs.umich.edu/mentalhealthsvcs, or for alcohol or drug concerns, see www.uhs.umich.edu/aodresources. For a listing of other mental health resources available on and off campus, visit http://umich.edu/~mhealth/. We are still in a pandemic; please take care of yourself.

Student Sexual Misconduct Policy

Title IX prohibits discrimination on the basis of sex, which includes sexual misconduct – including harassment, domestic and dating violence, sexual assault, and stalking. Sexual violence can undermine students' academic success and I encourage anyone dealing with sexual misconduct to talk to someone about their experience, so that they can get the support they need. Confidential support and academic advocacy can be found with the Sexual Assault Prevention and Awareness Center (SAPAC) on their 24-hour crisis line 734-936-3333 and at https://sapac.umich.edu. Alleged violations can be reported to the Office for Equity, Civil Rights, and Title IX (ECRT) at https://ecrt.umich.edu/ .

CLIMATE/SPACE 501-004 Course Outline (Fall 2023)

Date	Topic	Instructor
W Aug 30	Introduction to the class, initial conversation	Liemohn/all
W Sep 6	PhD job description, student rights and responsibilities	Bassis
W Sep 13	Personal finance as a grad student	Liemohn
W Sep 20	Advisor relations	Steiner
W Sep 27	Reading scientific literature	Liemohn
W Oct 4	Developing a 5-year plan	Liemohn
W Oct 11	Project management	Liemohn
W Oct 18	Practices of Good Mentoring (you as mentor)	Bassis
W Oct 25	Data management and reproducibility in scientific research	Liemohn
W Nov 1	Sparking scientific creativity	Liemohn
W Nov 8	Scientific publication process	Steiner
W Nov 15	Github tutorial	Welling
W Nov 22	**No class,** Thanksgiving Break	--
W Nov 29	Academic networking, making the most of conferences	Bassis
W Dec 6	Community engagement, final conversation	Liemohn

Assignments

Assigned	Due	Description
W Aug 30	W Dec 6	Professional development activity, seminar, workshop
W Sep 20	W Dec 6	Draft mentoring plan
W Oct 25	W Dec 6	Draft data management plan

CLIMATE/SPACE 501-004: CLaSP PhD Professional Seminar
Course Conduct Statement

Profs. Mike Liemohn, Allison Steiner, and Jeremy Bassis

The College of Engineering has an honor code. This is taken seriously.
See the website: http://www.engin.umich.edu/students/honorcode/code/

Policy on Homework and Projects

You are encouraged to form study groups to work on homework problems and to study in other ways. You are allowed to consult with other students during the conceptualization of a problem. However, all written work, whether in scrap or final form, is to be generated by you alone. You are not allowed to possess, look at, use, or in any way derive advantage from the existence of solutions prepared in prior years, whether these solutions were former students' work product or copies of solutions that had been made available by others.

Unless arrangements are made with me beforehand, late assignments are marked down by 10% per day and will not be accepted after one week or when it is graded and returned, whichever is first.

Violations

Violation of this policy is grounds for the initiation of a report filed with the Dean's office and the case would come before the Honor Council of the College of Engineering. If you have any questions about this policy, then please do not hesitate to contact me.

University of Michigan
Fall 2023 Instructor Report
CLIMATE 501 004 - SPACE 501 004
Jeremy Bassis

12 out of 12 students responded to this evaluation.

Responses to University-wide questions about the course:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
This course advanced my understanding of the subject matter. (Q1631)	6	4	2	0	0	0	4.5	4.5	4.5
My interest in the subject has increased because of this course. (Q1632)	5	3	2	0	0	2	4.5	4.2	4.2
I knew what was expected of me in this course.(Q1633)	9	1	1	0	0	1	4.9	4.4	4.5
I had a strong desire to take this course.(Q4)	6	3	2	1	0	0	4.5	4.1	4.0
As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891)	6	3	3	0	0	0	4.5	2.8	3.0

Responses to University-wide questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
Jeremy Bassis seemed well prepared for class meetings.(Q230)	9	2	0	0	0	0	4.9	4.7	4.8
Jeremy Bassis explained material clearly.(Q199)	10	2	0	0	0	0	4.9	4.6	4.7
Jeremy Bassis treated students with respect.(Q217)	11	1	0	0	0	0	5.0	4.8	4.8

Responses to questions about the course:

	SA	A	N	D	SD	N/A	Your Median
Overall, this was an excellent course. (Q1)	9	1	2	0	0	0	4.8

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Jeremy Bassis was an excellent teacher. (Q2)	9	3	0	0	0	0	4.8
Jeremy Bassis acknowledged all questions insofar as possible. (Q216)	9	3	0	0	0	0	4.8
Jeremy Bassis encouraged constructive criticism. (Q218)	9	3	0	0	0	0	4.8

The medians are calculated from Fall 2023 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 1 to 15 in College of Engineering.

University of Michigan
Fall 2023 Instructor Report
CLIMATE 501 004 - SPACE 501 004
Mike Liemohn

12 out of 12 students responded to this evaluation.

Responses to University-wide questions about the course:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
This course advanced my understanding of the subject matter. (Q1631)	6	4	2	0	0	0	4.5	4.5	4.5
My interest in the subject has increased because of this course. (Q1632)	5	3	2	0	0	2	4.5	4.2	4.2
I knew what was expected of me in this course.(Q1633)	9	1	1	0	0	1	4.9	4.4	4.5
I had a strong desire to take this course.(Q4)	6	3	2	1	0	0	4.5	4.1	4.0
As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891)	6	3	3	0	0	0	4.5	2.8	3.0

Responses to University-wide questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
Mike Liemohn seemed well prepared for class meetings.(Q230)	9	2	0	0	0	0	4.9	4.7	4.8
Mike Liemohn explained material clearly.(Q199)	10	2	0	0	0	0	4.9	4.6	4.7
Mike Liemohn treated students with respect.(Q217)	11	1	0	0	0	0	5.0	4.8	4.8

Responses to questions about the course:

	SA	A	N	D	SD	N/A	Your Median
Overall, this was an excellent course. (Q1)	9	1	2	0	0	0	4.8

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Mike Liemohn was an excellent teacher. (Q2)	9	3	0	0	0	0	4.8
Mike Liemohn acknowledged all questions insofar as possible. (Q216)	9	3	0	0	0	0	4.8
Mike Liemohn encouraged constructive criticism. (Q218)	9	3	0	0	0	0	4.8

The medians are calculated from Fall 2023 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 1 to 15 in College of Engineering.

University of Michigan
Fall 2023 Instructor Report
CLIMATE 501 004 - SPACE 501 004
Allison Steiner

12 out of 12 students responded to this evaluation.

Responses to University-wide questions about the course:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
This course advanced my understanding of the subject matter. (Q1631)	6	4	2	0	0	0	4.5	4.5	4.5
My interest in the subject has increased because of this course. (Q1632)	5	3	2	0	0	2	4.5	4.2	4.2
I knew what was expected of me in this course.(Q1633)	9	1	1	0	0	1	4.9	4.4	4.5
I had a strong desire to take this course.(Q4)	6	3	2	1	0	0	4.5	4.1	4.0
As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891)	6	3	3	0	0	0	4.5	2.8	3.0

Responses to University-wide questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
Allison Steiner seemed well prepared for class meetings.(Q230)	10	2	0	0	0	0	4.9	4.7	4.8
Allison Steiner explained material clearly.(Q199)	10	2	0	0	0	0	4.9	4.6	4.7
Allison Steiner treated students with respect.(Q217)	12	0	0	0	0	0	5.0	4.8	4.8

Responses to questions about the course:

	SA	A	N	D	SD	N/A	Your Median
Overall, this was an excellent course. (Q1)	9	1	2	0	0	0	4.8

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Allison Steiner was an excellent teacher. (Q2)	9	3	0	0	0	0	4.8
Allison Steiner acknowledged all questions insofar as possible. (Q216)	9	3	0	0	0	0	4.8
Allison Steiner encouraged constructive criticism. (Q218)	9	3	0	0	0	0	4.8

The medians are calculated from Fall 2023 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 1 to 15 in College of Engineering.

1210 LSA Building
500 S. State Street
Ann Arbor, MI 48109-1382
Phone: 734.763.2113
Fax: 734.936.3148
ro.curriculum@umich.edu
ro.umich.edu

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-08
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Computer Science and Engineering Subject: CSE Catalog: 598	Dept (Home): Computer Science and Engineering Subject: CSE Catalog: 598
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Special Topics	Course Title (full title) Special Topics
☐	Abbreviated Title (20 char) Special Topics	Abbreviated Title (20 char) Special Topics
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Topics of current interest in computer science and engineering. Lectures, seminar or laboratory. Can be taken more than once for credit.	
☐	Full Term Credit Hours Undergraduate Min: 1 Graduate Min: 1 Undergraduate Max: 4 Graduate Max: 4	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student, Rackham Graduate Student	
☐	Repeatability ☑ Course is Repeatable for Credit Maximum number of repeatable credits: 999	☐ Course is Y graded ☑ Can be taken more than once in the same term

Subject: Computer Science and Engineering Catalog: 598

☐

Grading Basis
- ☑ Graded (A – E)
- ☐ Credit/No Credit
- ☐ Satisfactory/Unsatisfactory
- ☐ Pass/Fail
- ☐ Business Administration

Grading
- ☐ Not for Credit
- ☐ Not for Degree Credit
- ☐ Degree Credit Only

Add Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

Drop Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

	CURRENT LISTING	REQUESTED LISTING
☐	Advisory Prerequisite (254 char) Permission of instructor or counselor	Advisory Prerequisite (254 char) Permission of instructor or counselor
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑

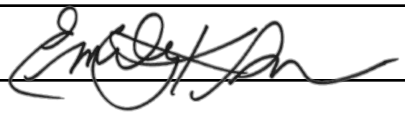
Course Components / Graded Component
- ☑ Lecture — ☑
- ☑ Seminar — ☐
- ☐ Recitation — ☐
- ☑ Lab — ☐
- ☑ Discussion — ☐
- ☐ Independent Study — ☐

Terms Typically Offered
- ☑ Fall
- ☑ Winter
- ☐ Spring
- ☐ Summer
- ☐ Spring/Summer

Cognizant Faculty Member Name: Emily Mower Provost Cognizant Faculty Member Title:

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Punam Vyas Email:vyas@umich.edu Phone:734-647-1754

CoE Curriculum Committee Representative:		Print: Amir Kamil	Date: 2/13/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Emily Mower Provost	Date:2/8/24
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description Topics of current interest in computer science and engineering. Lectures, seminar, or laboratory. Can be taken more than once for credit.	Course Description Topics of current interest in computer science and engineering. Lectures, seminar or laboratory. Can be taken more than once for credit.
Class Length Full term	Class Length Full term
Contact hours (lecture):	Contact hours (lecture):
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
CSE 598 is a special-topics course. Course components vary by offering, so we are selecting lab and discussion components to allow offerings to include those components. The CoE Policy for the Assignment of Credit Hours will be followed when scheduling course components.

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Fax: 734.936.3148

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ CHECK APPROPRIATE BOXES FOR ALL CHANGES

Action Requested
- ☑ New Course
- ☐ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-05
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☑	Dept (Home): Subject: Catalog:	Dept (Home): Electrical & Computer Engineering Subject: ECE Catalog: 510
☐	☐ Course is Cross-Listed with Other Departments	☑ Course is Cross-Listed with Other Departments
	Department / Subject / Catalog Number	Department / Subject / Catalog Number
☑		Nuclear Engineering & Radiological Sciences - NERS - 675
☑	Course Title (full title)	Course Title (full title) Plasma Chemistry and Plasma Surface Interactions
☑	Abbreviated Title (20 char)	Abbreviated Title (20 char) Plasma Chem
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Focuses on the plasma chemistry and plasma-surface interactions occurring in low temperature plasmas as used in, for example, materials processing, chemical conversion, biotechnology, environmental remediation, and photon sources. Emphasis is on the atomic and molecular processes that produce chemically reactive species by electron and ion-molecule collisions, neutral-neutral reactions; and reactions with inorganic, organic and liquid surfaces. Plasma-surface interactions will be addressed that result in deposition, etching and sputtering. Radiation transport producing photoionization and photodissociation, and trapping will be discussed.	
☑	Full Term Credit Hours Undergraduate Min: 3 Graduate Min: 3 Undergraduate Max: 3 Graduate Max: 3	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☑	Course Credit Type Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject:	Catalog:

☑	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☑	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char) ECE 517, permission of instructor, or graduate standing
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☐ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Mark J Kushner	Cognizant Faculty Member Title: Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Nancy Slowey Email: nslowey@umich.edu Phone: 734-763-2305

CoE Curriculum Committee Representative:	Achilleas Anastasopoulos	Print: Achilleas Anastasopoulos	Date: 2/28/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:	Heath Hofmann	Print: Heath Hofmann	Date: 2/26/24
Cross-Listed Department Chair:	Todd Allen	Print: Todd Allen	Date: 29 Feb 2024
Cross-Listed Department Chair:		Print:	Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description	Course Description Focuses on the plasma chemistry and plasma-surface interactions occurring in low temperature plasmas as used in, for example, materials processing, chemical conversion, biotechnology, environmental remediation, and photon sources. Emphasis is on the atomic and molecular processes that produce chemically reactive species by electron and ion-molecule collisions, neutral-neutral reactions; and reactions with inorganic, organic and liquid surfaces. Plasma-surface interactions will be addressed that result in deposition, etching and sputtering. Radiation transport producing photoionization and photodissociation, and trapping will be discussed.
Class Length	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:
None

Supporting statement:
This class has been offered several times as the special topics course EECS 598/NER590 Plasma Chemistry and Plasma Surface Interactions. Enrollment varies from a low of 6-10 to a high of 15-20. Students from several departments (ChemE, ECE, NERS, ME, AeroE, CLaSP) take this course, as the topics are of interest to a wide range of materials and chemical processing applications. There is no other offering at UM that provides this course content.

Version 02

EECS 598-001 / NERS 590-001
Plasma Chemistry and Plasma Surface Interactions
Winter 2020, MW 9:00–10:30 AM, 1008 EECS

Instructor: **Mark J. Kushner**
2236 EECS Building (734-647-1695)
Office Hours: Tuesday, Thursday, 3-5 pm; or by appointment
e-mail: mjkush@umich.edu

Goals and overview of course: This course addresses the fundamental science and technology of plasma activated chemistry occurring in low temperature plasmas, and plasma-surface interactions of materials in contact with these plasmas. The plasma chemical systems of interest are those used in, for example, materials processing (e.g., etching, deposition, sputtering) at low pressure and atmospheric pressure air plasmas as used in toxic gas remediation, functionalization of polymers, treatment of liquids or plasma medicine. The intent of the course is to provide a sufficient knowledge base in the fundamental processes occurring in these systems. Using that knowledge base, models of plasma chemical systems (volume and surface processes) of arbitrary composition can be developed. To accomplish these goals, we will discuss fundamental processes that describe the interaction of electrons with atoms and molecules, ion-molecule reactions, neutral-neutral reactions; and reactions of those species with surfaces. We will start with less complex systems, such as rare gas plasmas, and increase complexity to multi-component plasmas as used in plasma etching and humid air plasmas. During this course, students will develop a global plasma chemistry model of increasing complexity capable of simulating these systems.

Text: As this is a special topics course, there is no single text that covers all of the materials. The closest reference text, and the required textbook is

A. Fridman, Plasma Chemistry (Cambridge University Press, New York, 2008)

There is an electronic version of this text available to you – and I recommend using the electronic version until such time that buying the hard copy is a good investment for you.

Electronic Version:

https://www.cambridge.org/core/books/plasma-chemistry/842EA140F5D8C59F15AB82544A3E44CC

This website parses out the chapters one at a time. I have compiled a single PDF file of the text, which can be downloaded from the Canvas course website. (Files > Textbook)

Course Website: A Canvas website is available for distribution of class materials. The site is accessible from https://canvas.it.umich.edu/ listed under "EECS 598 001 WN 2024". You should have access to this site by being enrolled in either EECS 598 001 or NERS 590 001. If you do not have access, please contact Prof. Kushner (mjkush@umich.edu).

Prior Preparation: We will briefly review the basic concepts of low temperature plasmas, however we assume that students taking this course have a working familiarity with low

temperature plasmas. This background knowledge includes the concepts of ambipolar diffusion, electron energy distributions, cross section, rate coefficients, self-sustaining electric fields, sheaths, dc glows and rf discharges. This preparation would be the equivalent of EECS 517 / NERS 578 *Introduction to Low Temperature Plasmas*.

Handouts and Class notes: Handouts are available on the Canvas website under Files > Handouts_Notes. The posted version of the handouts will be periodically updated.

A copy of my hand-written class notes are available on the Canvas website under Files > Handouts_Notes. These notes are provided as a backup to your own notes taken in class and will be periodically updated.

There is no guarantee everything covered in class are in these notes!!!
There is no guarantee that everything in the notes will be covered in class!!!
Come to class, take your own notes, use these as backup!!!

Grading Policy: Plasma chemistry is intrinsically an interdisciplinary field with many fundamental concepts that feed into higher level processes. These linkages are difficult to appreciate in the absence of *practicing the craft*. So there is considerable emphasis on homework ("mini-projects") as part of the learning process. A final project will provide the student with an opportunity to apply what has been learned. The grading policy will be:

Homework	35%
Mid-Term Exam	30%
Final Project	35%
Instructor's discretion	5%

Lecture-Recordings: Lectures will be recorded through the CAEN lecture capture system, and made available through the Canvas website. With the course being recorded, as part of your participation in this course your voice or image may be also recorded. The in-class camera will not be directed towards the student seating, however, your image may be recorded if you look back at the camera or step to the front of the classroom. Your voice will likely be recorded if you ask a question in-person during class. Students are prohibited from recording/distributing any class activity without written permission from the instructor, except as necessary as part of approved accommodations for students with disabilities. Any approved recordings may only be used for the student's own private use. Please let me know if you have any questions.

A Welcoming and Respectful Class: As instructor in this class, I aim to provide a welcoming, respectful, mentoring and collegial learning environment for all students of all backgrounds, beliefs and identities. I hope and expect that all students in the class share that same goal. If at any time you feel that the class is not meeting this goal, or you have any suggestions on how to provide a better learning environment, please contact me.

Students with Disabilities: If you have a disability that requires special accommodation (e.g., extra exam time), please contact the Services for Students with Disabilities (SSD) office (G-664 Haven Hall, 734-763-3000, http://ssd.umich.edu).

Version 02

Class Schedule and Makeup Classes: The tentative class schedule is shown below. Prof. Kushner will have periodic travel and we will have make-up classes at Fridays at 8:00 am for those missed classes. The early hour is because there are no classrooms available at reasonable hours. (Sorry about the early hour.)

Week	M	T	W	Th	F
Jan. 8			**No Class**		Makeup Class
Jan. 15	MLK Day No Class		Class MIPSE Seminar		
Jan. 22	Class		Class		Makeup Class
Jan. 29	**No Class**		**No Class**		
Feb. 5	Class		Class MIPSE Seminar		Makeup Class
Feb. 12	Class		Class		
Feb. 19	Class		Class		
Feb. 26	Spring Break No Class		Spring Break No Class		
Mar. 4	Class		Class MIPSE Seminar		
Mar. 11	Class		Class		
Mar. 18	Class (Exam)		Class MIPSE Seminar		
Mar. 25	Class		Class – Midterm Exam		
Apr. 1	Class		Class		
Apr. 8	Class		Class		
Apr. 15	Class		Class MIPSE Seminar		
Apr. 22	Class				Projects Due

Projects

Instead of a final exam, there will be a final project for this class. The project should consist of developing a model for or performing an in depth analysis of a low temperature plasma chemical system that interacts with the surfaces in contact with the plasma. During the course a global plasma chemistry model will be developed, and that model can be (should be) used in the final project.

The project should include a literature search to provide you with background on the basics of the plasma chemical system you have chosen to study and to see how other researchers have analyzed the system. Some of the models which appear in the literature are quite involved and complex. The intent of the project is not for you to duplicate the complexity of those models. Rather, the intent is to give you some sense of how the device and the "final product" (e.g., deposition rate, etching rate, rate of removal of toxic gas) scale. Your model should have at least the degree of sophistication of the global model developed in class, but should include real device parameters. For example, use the actual gas pressures, gas mixtures, dimensions, cross sections, currents, and voltages.

Your final project deliverables will consist of the written report. The limit on length is 25 pages, though 25 pages are not required. (Fewer pages of higher quality are preferred.) Please include a description of the discharge system, how you have analyzed it, the scaling laws you developed and a discussion of what you have learned. Generously use plots to display parametric results.

Due date: Friday, 26 April 2024, 5:00 PM
Paper copy to: Prof. Kushner office (2236 EECS)
PDF copy to: mjkush@umich.edu

Version 02

EECS 598-001 / NERS 590-001
Plasma Chemistry and Plasma Surface Interactions
Winter 2024 Syllabus and Reading Assignments (v01)

Unit	Topic	Reading Assignment (Fridman)
1.0	Introduction	Ch. 1
Gas Phase Plasma Chemistry		
2.1	Quick Review of Glow Discharges	4.2
2.2	Basic Global Plasma Chemistry Model	Handout
2.3	Kinetics	3.1
2.4	Rate Coefficients and Electron Impact Processes	3.1
2.5	Thermodynamics	3.1
2.6	Atomic and Molecular Spectra	
2.7	Charge Exchange, cluster ions, 3-body reactions	2.2
2.8	Transport Coefficients: Neutrals	3.3
2.9	Transport Coefficients: Ions	3.3
2.10	Transport Coefficients: Electrons and Electron Impact Cross Sections and Processes	2.5
2.11	Vibrational Collisions: VT, VV	2.6
2.12	Gas heating in low pressure plasmas	
2.13	Charged Particle Neutralization: Ion-Ion	2.3
2.14	Charged Particle Neutralization: Electron Ion Recombination	2.2
2.15	Radiation Transport	3.3
3.1	Rare Gas Plasma Chemistry: (low pressure and high pressure)	4.1, 4.2, 4.5
3.2	Stability of Atmospheric Pressure Plasmas and Dielectric Barrier Discharges	4.3, 4.5
3.3	Air Plasma Chemistry (Dry and Humid)	Handouts
3.4	Plasma Etching Chemistries	8.2, 8.3, Handouts
3.5	Plasma Deposition Chemistries	8.5, Handouts
3.6	Plasma Remediation of Gases	11.7
Plasma Surface Interactions		
4.1	Deposition	Handouts
4.2	Functionalization of Polymers	9.7, 9.8
4.3	Sputtering and Ion Implantation	8.5, 8.6
4.4	Chemically Enhanced Sputtering	8.2
4.5	Biological Surfaces	12

Plasma Initiated Liquid Chemistry		
5.1	Electron and ion reactions at liquid surfaces	
5.2	Liquid phase chemistry	

Textbook:
A. Fridman, Plasma Chemistry (Cambridge University Press, New York, 2008)

University of Michigan
Fall 2020 Instructor Report With Comments
EECS 598 004 - EECS 598 904 - NERS 590 004 - NERS 590 804
Mark Kushner

7 out of 13 students responded to this evaluation.

Responses to University-wide questions about the course:

	SA	A	N	D	SD	N/A	Your Median	Univ-wide Median	School/College Median
This course advanced my understanding of the subject matter. (Q1631)	5	2	0	0	0	0	4.8	4.6	4.5
My interest in the subject has increased because of this course. (Q1632)	4	3	0	0	0	0	4.6	4.2	4.2
I knew what was expected of me in this course.(Q1633)	3	4	0	0	0	0	4.4	4.5	4.4
Overall, this was an excellent course.(Q1)	5	2	0	0	0	0	4.8	4.4	4.3
I had a strong desire to take this course.(Q4)	2	5	0	0	0	0	4.2	4.1	4.1
As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891)	1	0	5	1	0	0	3.0	2.9	2.8
How did you participate in this course? (Q1854)	3	3	0	1	0	0	4.3	4.7	4.5

Responses to University-wide questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median	Univ-wide Median	School/College Median
Overall, Mark Kushner was an excellent teacher.(Q2)	6	1	0	0	0	0	4.9	4.7	4.8
Mark Kushner seemed well prepared for class meetings.(Q230)	6	1	0	0	0	0	4.9	4.8	4.9
Mark Kushner explained material clearly.(Q199)	6	1	0	0	0	0	4.9	4.7	4.8
Mark Kushner treated students with respect.(Q217)	6	1	0	0	0	0	4.9	4.9	4.9

Responses to questions about the course:

	SA	A	N	D	SD	N/A	Your Median	University-Wide Median
Prerequisites provided adequate preparation for this course. (Q61)	4	2	1	0	0	0	4.6	4.5
The textbook made a valuable contribution to the course. (Q64)	2	3	1	0	0	1	4.2	3.9
I developed confidence in my abilities as an engineer. (Q1769)	4	3	0	0	0	0	4.6	4.2
I developed the ability to solve real world engineering problems. (Q1770)	4	3	0	0	0	0	4.6	4.2

The medians are calculated from Fall 2020 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 1 to 15 in College of Engineering.

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-08
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Electrical & Computer Engineering Subject: ECE Catalog: 598	Dept (Home): Electrical & Computer Engineering Subject: ECE Catalog: 598
☐	☐ Course is Cross-Listed with Other Departments	☐ Course is Cross-Listed with Other Departments
	Department / Subject / Catalog Number	Department / Subject / Catalog Number
☐		
☐	Course Title (full title) Special Topics	Course Title (full title) Special Topics
☐	Abbreviated Title (20 char) Special Topics	Abbreviated Title (20 char) Special Topics
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Topics of current interest in electrical computer and engineering. Lectures, seminar or laboratory. Can be taken more than once for credit.	
☐	Full Term Credit Hours Undergraduate Min: 1 Graduate Min: 1 Undergraduate Max: 4 Graduate Max: 4	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student, Rackham Graduate Student	
☐	Repeatability ☑ Course is Repeatable for Credit Maximum number of repeatable credits: 999	☐ Course is Y graded ☑ Can be taken more than once in the same term

Subject: Electrical & Computer Engineering Catalog: 598

☐

Grading Basis
- ☑ Graded (A – E)
- ☐ Credit/No Credit
- ☐ Satisfactory/Unsatisfactory
- ☐ Pass/Fail
- ☐ Business Administration

Grading
- ☐ Not for Credit
- ☐ Not for Degree Credit
- ☐ Degree Credit Only

Add Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

Drop Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

	CURRENT LISTING	REQUESTED LISTING
☐	Advisory Prerequisite (254 char) Permission of instructor or counselor	Advisory Prerequisite (254 char) Permission of instructor or counselor
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑

Course Components / Graded Component

	Graded Component
☑ Lecture	☑
☑ Seminar	☐
☐ Recitation	☐
☑ Lab	☐
☑ Discussion	☐
☐ Independent Study	☐

Terms Typically Offered
- ☑ Fall
- ☑ Winter
- ☐ Spring
- ☐ Summer
- ☐ Spring/Summer

Cognizant Faculty Member Name: Heath Hofmann Cognizant Faculty Member Title:

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Punam Vyas Email: vyas@umich.edu Phone:647-1754

CoE Curriculum Committee Representative:	Achilleas Anastasopoulos	Print: Anastasopoulos, Achilleas	Date:2/8/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:	Heath Hofmann	Print: Heath Hofmann	Date:2/8/24
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description Topics of current interest in electrical computer and engineering. Lectures, seminar or laboratory. Can be taken more than once for credit.	Course Description Topics of current interest in electrical computer and engineering. Lectures, seminar or laboratory. Can be taken more than once for credit.
Class Length Full term	Class Length Full term
Contact hours (lecture):	Contact hours (lecture):
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
ECE 598 is a special-topics course. Course components vary by offering, so we are selecting lab and discussion components to allow offerings to include those components. The CoE Policy for the Assignment of Credit Hours will be followed when scheduling course components.

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-12
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Elec Engin & Computer Sci Subject: EECS Catalog: 498	Dept (Home): Elec Engin & Computer Sci Subject: EECS Catalog: 498
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Special Topics	Course Title (full title) Special Topics
☐	Abbreviated Title (20 char) Special Topics	Abbreviated Title (20 char) Special Topics
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Topics of current interest selected by the faculty. Lecture, seminar or laboratory.	
☐	Full Term Credit Hours Undergraduate Min: 1 Graduate Min: 1 Undergraduate Max: 4 Graduate Max: 4	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student, Rackham Graduate Student	
☐	Repeatability ☑ Course is Repeatable for Credit Maximum number of repeatable credits: 999	☐ Course is Y graded ☑ Can be taken more than once in the same term

Subject: Elec Engin & Computer Sci Catalog: 498

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

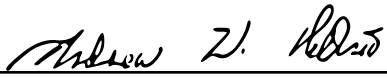
	CURRENT LISTING	**REQUESTED LISTING**
☐	Advisory Prerequisite (254 char) Permission of instructor	Advisory Prerequisite (254 char) Permission of instructor
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☑ Seminar ☐ Recitation ☑ Lab ☑ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☑ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Amir Kamil Cognizant Faculty Member Title:

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Punam Vyas Email: vyas@umich.edu Phone: 647-1754

CoE Curriculum Committee Representative:		Print:Amir Kamil	Date: 2/13/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Andrew W DeOrio	Date:2/12/24
Cross-Listed Department Chair:		Print: Heath Hofmann	Date: 2/14/24
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description Topics of current interest selected by the faculty. Lecture, seminar or laboratory.	Course Description Topics of current interest selected by the faculty. Lecture, seminar or laboratory.
Class Length Full term	Class Length Full term
Contact hours (lecture):	Contact hours (lecture):
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
EECS 498 is a special-topics course. Course components vary by offering, so we are selecting lab and discussion components to allow offerings to include those components. The CoE Policy for the Assignment of Credit Hours will be followed when scheduling course components.

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-26
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Engineering Subject: ENGR Catalog: 101	Dept (Home): Engineering Subject: ENGR Catalog: 101
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Introduction to Computers and Programming	Course Title (full title) Introduction to Computers and Programming
☐	Abbreviated Title (20 char) Intro Comp&Prog	Abbreviated Title (20 char) Intro Comp&Prog
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Algorithms and programming in C++ and Matlab, computing as a tool in engineering, introduction to the organization of digital computers.	
☐	Full Term Credit Hours Undergraduate Min: 4 Graduate Min: Undergraduate Max: 4 Graduate Max:	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Engineering Catalog: 101

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☐	Advisory Prerequisite (254 char) Prior or concurrent enrollment in MATH 115 or equivalent.	Advisory Prerequisite (254 char) Prior or concurrent enrollment in MATH 115 or equivalent.
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☑	Credit Exclusions Credit for only one: EECS 180, EECS 183, ENGR 101, or ENGR 151	Credit Exclusions Only 2 credits granted for ENGR 101 to those who have completed or are enrolled in ENGR 161; Credit for only one: EECS 180, EECS 183, ENGR 101, OR ENGR 151

☐	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☑ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☑ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Laura Alford Cognizant Faculty Member Title:

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Ryan Latimer Email: rlatimer@umich.edu Phone: 734-647-9039

CoE Curriculum

Committee Representative: Rachael Schmedlen Print: Rachael Schmedlen Date: 2/26/24

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Kevin Pipe Print: Kevin Pipe Date: 02/26/24

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description Algorithms and programming in C++ and Matlab, computing as a tool in engineering, introduction to the organization of digital computers.	Course Description Algorithms and programming in C++ and Matlab, computing as a tool in engineering, introduction to the organization of digital computers.
Class Length Full term	Class Length Full term
Contact hours (lecture): 3	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab) 2	Contact hours (lab) 2

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
Updating credit exclusions with creation of MATLAB course ENGR 161

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-21
Effective Term: Fall 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Engineering Subject: ENGR Catalog: 151	Dept (Home): Engineering Subject: ENGR Catalog: 151
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Accelerated Introduction to Computers and Programming	Course Title (full title) Accelerated Introduction to Computers and Programming
☐	Abbreviated Title (20 char) Accel Intro Prog	Abbreviated Title (20 char) Accel Intro Prog
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Algorithms and programming in C++ and matlab. Procedural and object-oriented algorithm design, implementation, and testing. Emphasis on engineering analysis and embedded computing application.	
☐	Full Term Credit Hours Undergraduate Min: 4 Graduate Min: Undergraduate Max: 4 Graduate Max:	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Engineering Catalog: 151

☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☐	Advisory Prerequisite (254 char) Previous experience with computer programming	Advisory Prerequisite (254 char) Previous experience with computer programming
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☑	Credit Exclusions Credit for only one: EECS 180, EECS 183, ENGR 101, OR ENGR 151	Credit Exclusions Only 2 credits granted for ENGR 151 to those who have completed or are enrolled in ENGR 161. Credit for only one: EECS 180, EECS 183, ENGR 101, OR ENGR 151

☐	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☑ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☑ Fall ☐ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Yang Zhang Cognizant Faculty Member Title:

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Ryan Latimer Email: rlatimer@umich.edu Phone: 734-647-9039

CoE Curriculum Committee Representative: Rachael Schmedlen Print: Rachael Schmedlen Date: 2/26/24

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Kevin Pipe Print: Kevin Pipe Date: 2/26/24

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description Algorithms and programming in C++ and matlab. Procedural and object-oriented algorithm design, implementation, and testing. Emphasis on engineering analysis and embedded computing application.	Course Description Algorithms and programming in C++ and matlab. Procedural and object-oriented algorithm design, implementation, and testing. Emphasis on engineering analysis and embedded computing application.
Class Length Full term	Class Length Full term
Contact hours (lecture): 3	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab) 2	Contact hours (lab) 2

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
Updating credit exclusions with creation of MATLAB course ENGR 161

1210 LSA Building
500 S. State Street
Ann Arbor, MI 48109-1382
Phone: 734.763.2113
Fax: 734.936.3148
ro.curriculum@umich.edu
ro.umich.edu

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☑ New Course
- ☐ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-03-01
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING			**REQUESTED LISTING**		
☑	Dept (Home): Subject: Catalog:			Dept (Home): Material Science Engineering Subject: MATSCIE Catalog: 506		
	☐ Course is Cross-Listed with Other Departments			☑ Course is Cross-Listed with Other Departments		
	Department	Subject	Catalog Number	Department	Subject	Catalog Number
☑				Macromolecular science and Engineering - MACROMOL - 506 Chemical Engineering - CHE -506		
☑	Course Title (full title)			Course Title (full title) Soft Robotic Matter		
☑	Abbreviated Title (20 char)			Abbreviated Title (20 char) Soft Robotic Matter		
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Soft robotic matter consists in active materials that can sense, move within, and alter their working environment. This course will explore fundamentals and emerging approaches in soft active matter design, actuation, power, and fabrication across length scales, with focus on engineering their properties and structures for programmable robotic functions.					
☑	Full Term Credit Hours Undergraduate Min: 3 Undergraduate Max: 3	Graduate Min: 3 Graduate Max: 3		Half Term Credit Hours Undergraduate Min: Undergraduate Max:	Graduate Min: Graduate Max:	
☑	Course Credit Type Undergraduate Student, Rackham Graduate Student					
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:			☐ Course is Y graded ☐ Can be taken more than once in the same term		

Subject: Catalog:

☑	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	REQUESTED LISTING
☐	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char)
☑	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Senior Standing or Graduate Standing Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☐ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Abdon Pena-Francesch Cognizant Faculty Member Title:

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Email: Phone:

CoE Curriculum Committee Representative:	EM	Print: Emmanuelle Marquis	Date: 3/1/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Elizabeth Holm	Date: 1/29/2024
Cross-Listed Department Chair:		Print: Jinsang Kim	Date: 2/1/2024
Cross-Listed Department Chair:		Print: Sharon Glotzer	Date: 2/13/24
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description	Course Description Soft robotic matter consists in active materials that can sense, move within, and alter their working environment. This course will explore fundamentals and emerging approaches in soft active matter design, actuation, power, and fabrication across length scales, with focus on engineering their properties and structures for programmable robotic functions.
Class Length	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
Course has been taught 2 time, and has had good enrollment

MSE 593: Special Topics
Soft Robotic Matter

Semester: Winter, 2024
Days/Times: Tuesday/Thursday 4:30 – 6:00 PM

Location: 1003 EECS

Professor: Abdon Pena-Francesch, Ph.D. (he/him)
Assistant Professor of Materials Science and Engineering, Macromolecular Science and Engineering, Chemical Engineering, Robotics Institute

Office: NCRC 28-3007E
Office Hours: by appointment
E-mail: abdon@umich.edu

I. Course Description

This course is aimed at *senior undergraduate* and *graduate students* with interests in materials science, robotics, functional soft materials, and bioengineering. While traditional robots are typically composed of rigid and hard materials, the growing field of soft robotics explores flexible and deformable materials to achieve compliance, dexterity, and functions akin to those of biological systems. Soft robotic materials design presents new opportunities to bypass inherent limitations in the design of devices, especially at small scales and when operating in unstructured environments. This course will explore fundamentals and emerging approaches in design, actuation, power, and control across length scales, with focus on leveraging the properties and structures of soft materials for programmable robotic functions.

II. Course Objectives

1. Development of an interdisciplinary perspective of materials, multiscale design, and robotics.
2. Development of foundation of soft matter physics, polymer chemistry, and manufacturing applied to robotics.
3. Explore approaches to engineering design and the role of materials in robotic functions and performance.
4. Understanding of structure-property-function relationships in a robotics context.
5. Learning the working principles of tethered and untethered actuation through materials design.
6. Understanding performance metrics and scaling laws in actuators across length scales.
7. Understanding materials interaction with their environment in a robotics context.
8. Introduce the state-of-the-art in the field through research articles, reviews, and conference technical programs.
9. Critical thinking and analysis of state-of-the-art technical literature.
10. Apply materials and structure design in soft microrobotics in a lab activity.
11. Development of communication skills through written reports and oral presentations.
12. Include discussions of ethical, societal, and environmental aspects in a robotics context.

III. Course Outcomes

After this course, a student:

1. Understands chemical and physical aspects to the design of functional polymer networks.
2. Understands fundamental structure-property-function relationships in active soft materials.
3. Understands physical scaling laws at macro-, micro-, and nanoscale length scales.
4. Can identify trade-offs among materials properties and actuator performance, and identify drivers in soft robot engineering design across length scales.
5. Can apply soft matter engineering to the design of small-scale soft robots using a variety of tethered and untethered actuation methods.
6. Can demonstrate the ability to justify materials engineering in soft robotic designs.
7. Can search and analyze technical information (including patents, reports, and technical research articles).
8. Can discuss study cases and critically analyze their design and performance.
9. Can write a high-quality technical report.
10. Can deliver excellent oral and poster presentations.

IV. Topics

1. Introduction to soft robotics
2. Introduction to soft materials
    - Intro to polymers, elastomers, and their material properties
    - Intro to smart materials
3. Tethered soft actuation: working principles, design, materials, and fabrication
    - Tendon-driven actuation
    - Pneumatic actuation
    - Electrical soft actuation (DEAs)
    - Artificial muscles: design, performance metrics, and applications
    - Soft grippers: design, performance metrics, and applications
4. Introduction to microrobotics.
    - Forces at the micro/nanoscale
    - Scaling laws for microrobots
    - Design principles at the micro/nanoscale
5. Untethered actuation: working principles, design, materials, fabrication, and power
    - Magnetic actuation
    - Electrical actuation
    - Acoustic actuation
    - Thermal actuation
    - Light-driven actuation
    - Chemical actuation
    - Eco-microrobots: environmental applications
    - Bio-microrobots: biomedical applications

V. Reference text

Mobile Microrobotics, Metin Sitti, The MIT Press, 2017 (*book not required*)

The course text will be supplemented with numerous research publications, review articles, and online resources.

VI. Tentative Schedule

Class	Date		Topic	Deliverables
1	Jan 11	Th	Introductions / Class logistics	
2	Jan 16	Tu	Soft Robotics - "hard" vs "soft" paradigm / Soft Matter I - Intro to polymer physics. Ideal chains.	
3	Jan 18	Th	Soft Matter II - Ideal chains and entropic elasticity. Polymer Networks	
4	Jan 23	Tu	Soft Matter III - Polymer Networks. Finite chains and linear viscoelasticity	
5	Jan 25	Th	Sort Matter IV - Applications of soft matter in robotics	
6	Jan 30	Tu	No class	
7	Feb 1	Th	Soft actuators: design, performance metrics, and applications	
8	Feb 6	Tu	Biological structural materials	HW I
9	Feb 8	Th	Continuum soft robots: tendon-driven robots and actuators	
10	Feb 13	Tu	Fluidic actuation: hydrostats & pneumatic actuators	
11	Feb 15	Th	**Guest lecture: Dr. Abby Juhl** (AFRL) (F 16th MSE seminar) Metamaterials for aerodynamic control	Select paper APS
12	Feb 20	Tu	DEAs & electroactive materials	
13	Feb 22	Th	Thermal actuation & shape memory alloys	Paper report I
-	Feb 27/29		Spring Break	
14	Mar 5	Tu	**Guest lecture: Prof. Hamed Shahsavan** (U Waterloo) Liquid crystal elastomers & light-driven robots	Select paper MRS
15	Mar 7	Th	Hydrogels / Self-healing robots & actuators	
16	Mar 12	Tu	Forces at the micro/nanoscale. Scaling laws	
17	Mar 14	Th	Chemical actuation - self-propelled robots	Paper report II
18	Mar 19	Tu	**Guest lecture: Prof. Amirreza Aghakhani** (U Stuttgart) Acoustic microrobots	
19	Mar 21	Th	Magnetic actuation - magnetic field fundamentals	Swimmer design
20	Mar 26	Tu	Magnetic actuation - soft/hard magnetic materials	
21	Mar 28	Th	Biohybrid microrobots	
22	Apr 2	Tu	**Lab visit** (microswinner race)	Swimmer race
23	Apr 4	Th	Presentations	Presentation
24	Apr 9	Tu	Presentations	Presentation
25	Apr 11	Th	Presentations	Presentation
26	Apr 16	Tu	Presentations	Presentation
27	Apr 18	Th	No class (buffer slot)	
28	Apr 23	Tu	No class	

VII. Assessment tools

Evaluation of written reports for written communication
Evaluation of oral presentations for oral communication
Evaluation of the design of a small-scale chemical swimmer robot
Participation in class discussions

VIII. Academic Integrity

Short version: Do your own work, don't lie, don't cheat. Give credit where credit is due.
Longer version: here.

IX. Grading

Homework set I: 10%
Lab activity I: 20%
Paper report I: 20%
Paper report II: 20%
Final presentation: 30%

X. Use of Generative Artificial Intelligence (GAI)

Generative AI (Artificial Intelligence that can produce contents) is now widely available to produce text, images, and other media. You can freely use such AI resources to inform yourself about the field, to understand the contributions that AI can make, and to help your learning.
In principle you may submit material that contains AI-generated text, or is based on or derived from it, as long as this use is *properly documented and justified*. This includes for example drafting an outline, finding information, revising for grammar and style, combining elements and removing redundant parts, or compiling and annotating references.
The use of generative AI tools is not permitted in this course for impersonating you in classroom contexts, completing group work that your group has assigned to you (unless it is mutually agreed upon that you may utilize the tool), writing a draft of a writing assignment, writing entire sentences, paragraphs or papers to complete class assignments.
However, please keep the following three principles in mind:

(1) An AI cannot pass this course. This is necessary to ensure you are competent to surpass generative AI in the future – whether in academia, research, industry, or any other domains of society. If this cannot be achieved, if you are not able to maintain control of the rules, you are entering an unwinnable competition. Because of this, the minimum passing requirements are likely higher than what we would have accepted previously. Your project contributions will be assessed based on your critical thought processes, discussions, and communication efforts rather than on a single end result, and you will be expected to demonstrate a level of competence that can and must surpass AI.

(2) AI contributions must be attributed and true. You are taking full responsibility for AI-generated materials as if you had produced them yourself: ideas must be attributed and facts must be true.

(3) The use of AI resources must be open and documented. Your documentation must make the process transparent – the submission itself must meet our standards of attribution and validation.

Misusing GAI resources and/or failure to disclose it will be considered a violation of the academic integrity code, and will be treated and reported as academic misconduct with according consequences.

XI. Attendance Policy

Attendance and punctuality are basic requirements for an effective discussion in this class. Beyond that, each person's frequency and quality of contribution to the class discussion will be assessed and reflected in the class participation score. If you cannot attend a class it is a courtesy to inform your group or team members and your professor in advance if possible. Excessive unexcused absence will result in your final grade lowered and/or recommending that you withdraw from the course.

XII. Syllabus Inclusion Statement

It is my intention that students from all backgrounds and perspectives will be well served by this course, and that the diversity that students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, socioeconomic background, family education level, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. Your suggestions are encouraged and appreciated.

XIII. Syllabus is in flux…

This syllabus is subject to revision. Developments in the class are in flux and the guidelines and policies expressed in this syllabus may need to change on short notice. This may affect the contents of assignments, their evaluation, dates, or any other part of the syllabus. All changes affecting the syllabus contents and overall class logistics will be discussed with the class and announced as soon as possible.

University of Michigan
Winter 2022 Instructor Report With Comments
MATSCIE 593-077: MSE Special Topics
Abdon Pena-Francesch

21 out of 24 students responded to this evaluation.

Responses to University-wide questions about the course:

	SA	A	N	D	SD	N/A	Your Median	Univ-wide Median	School/College Median
This course advanced my understanding of the subject matter. (Q1631)	17	3	1	0	0	0	4.9	4.6	4.7
My interest in the subject has increased because of this course. (Q1632)	15	5	1	0	0	0	4.8	4.2	4.6
I knew what was expected of me in this course.(Q1633)	17	3	1	0	0	0	4.9	4.6	4.5
I had a strong desire to take this course.(Q4)	13	5	2	0	0	0	4.7	4.1	4.5
As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891)	4	11	6	0	0	0	3.9	3.0	3.0

Responses to University-wide questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median	Univ-wide Median	School/College Median
Abdon Pena-Francesch seemed well prepared for class meetings.(Q230)	18	2	1	0	0	0	4.9	4.8	4.8
Abdon Pena-Francesch explained material clearly.(Q199)	16	4	1	0	0	0	4.8	4.7	4.7
Abdon Pena-Francesch treated students with respect. (Q217)	19	1	1	0	0	0	4.9	4.8	4.9

Responses to questions about the course:

	SA	A	N	D	SD	N/A	Your Median
Overall, this was an excellent course. (Q1)	17	3	1	0	0	0	4.9

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Abdon Pena-Francesch was an excellent teacher. (Q2)	19	1	1	0	0	0	4.9

The medians are calculated from Winter 2022 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 16 to 74 in College of Engineering.

University of Michigan
Winter 2023 Instructor Report
MATSCIE 593-077: MSE Special Topics
Abdon Pena-Francesch

15 out of 21 students responded to this evaluation.

Responses to University-wide questions about the course:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
This course advanced my understanding of the subject matter. (Q1631)	11	4	0	0	0	0	4.8	4.4	4.5
My interest in the subject has increased because of this course. (Q1632)	12	3	0	0	0	0	4.9	4.1	4.2
I knew what was expected of me in this course.(Q1633)	6	9	0	0	0	0	4.3	4.3	4.6
I had a strong desire to take this course.(Q4)	12	2	1	0	0	0	4.9	4.0	4.1
As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891)	3	11	1	0	0	0	4.1	2.8	3.0

Responses to University-wide questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
Abdon Pena-Francesch seemed well prepared for class meetings.(Q230)	13	2	0	0	0	0	4.9	4.7	4.8
Abdon Pena-Francesch explained material clearly.(Q199)	12	3	0	0	0	0	4.9	4.6	4.7
Abdon Pena-Francesch treated students with respect. (Q217)	13	2	0	0	0	0	4.9	4.8	4.8

Responses to questions about the course:

	SA	A	N	D	SD	N/A	Your Median
Overall, this was an excellent course. (Q1)	12	2	1	0	0	0	4.9

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Abdon Pena-Francesch was an excellent teacher. (Q2)	12	2	1	0	0	0	4.9

The medians are calculated from Winter 2023 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 16 to 74 in College of Engineering.

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☑ New Course
- ☐ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-01-26
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☑	Dept (Home): Subject: Catalog:	Dept (Home): Material Science Engineering Subject: MATSCIE Catalog: 509
☐	☐ Course is Cross-Listed with Other Departments	☑ Course is Cross-Listed with Other Departments
	Department / Subject / Catalog Number	Department / Subject / Catalog Number
☑		Biomedical Engineering - BIOMEDE - 509 Chemical Engineering - CHE - 509 Macromolecular Science and Engineering - MACROMOL - 509
☑	Course Title (full title)	Course Title (full title) Advanced Biomaterials
☑	Abbreviated Title (20 char)	Abbreviated Title (20 char) Adv Biomaterials
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Biomaterials have important roles and growing impact on broad applications, including medical devices, implants, regenerative medicine, tissue engineering, sensors, diagnostics, and drug delivery. This graduate level course is designed primarily for graduate and senior undergraduate students in engineering or biological sciences, as a complement to BME 410. It will cover both basic concepts and contemporary concepts and applications in advanced biomaterials.	
☑	Full Term Credit Hours Undergraduate Min: 3 Graduate Min: 3 Undergraduate Max: 3 Graduate Max: 3	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☑	Course Credit Type Undergraduate Student, Rackham Graduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Catalog:

☑ Grading Basis
- ☑ Graded (A – E)
- ☐ Credit/No Credit
- ☐ Satisfactory/Unsatisfactory
- ☐ Pass/Fail
- ☐ Business Administration

Grading
- ☐ Not for Credit
- ☐ Not for Degree Credit
- ☐ Degree Credit Only

Add Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

Drop Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

	CURRENT LISTING	REQUESTED LISTING
☑	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char) MATSCIE 220 or MATSCIE 250
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑ Course Components
- ☑ Lecture
- ☐ Seminar
- ☐ Recitation
- ☐ Lab
- ☐ Discussion
- ☐ Independent Study

Graded Component
- ☑
- ☐
- ☐
- ☐
- ☐
- ☐

Terms Typically Offered
- ☐ Fall
- ☑ Winter
- ☐ Spring
- ☐ Summer
- ☐ Spring/Summer

Cognizant Faculty Member Name: Geeta Mehta

Cognizant Faculty Member Title:

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Email: Phone:

CoE Curriculum Committee Chair:		Print:	Date:
CoE Curriculum Committee Representative:	E Marquis	Print: Emmanuelle Marquis	Date: 2/20/2024
Home Department Chair:		Print: Elizabeth Holm	Date: 1/29/2024
Cross-Listed Department Chair:		Print: Jinsang Kim	Date: 2/1/2024
Cross-Listed Department Chair:		Print: Sharon C. Glotzer	Date: 2/14/24
Cross-Listed Department Chair:		Print: Tim Bruns	Date: 02/14/2024

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description	Course Description Biomaterials have important roles and growing impact on broad applications, including medical devices, implants, regenerative medicine, tissue engineering, sensors, diagnostics, and drug delivery. This graduate level course is designed primarily for graduate and senior undergraduate students in engineering or biological sciences, as a complement to BME 410. It will cover both basic concepts and contemporary concepts and applications in advanced biomaterials.
Class Length	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
Course has been taught for more t2 terms and has good enrollment

Course Syllabus for Winter 2024

MATSCIE 593 - 053 **Advanced Biomaterials** (3 Credits)

Semester: Winter, 2024

Days/Times: Monday/Wednesday 12:00 PM - 1:30 PM

***Classroom*:** 1008 EECS

Instructional Staff:

Professor: Geeta Mehta, Ph.D., Associate Professor, Depts. of Materials Science and Engineering, Biomedical Engineering, and Macromolecular Science and Engineering

E-mail: mehtagee@umich.edu

Please see Communications section for notes about contacting the instructor

Office Hours: By appointment either on Zoom or in NCRC

Prerequisites:

This course is intended for graduate students in MSE, BME, CHE, Macro, Chemistry, ME, and PIBS. There are no formal prerequisites, but students are advised to have completed an introductory course in materials or biomaterials, and basic knowledge of chemistry, materials science and engineering, & biochemistry/cell biology concepts.

Communications Policy:

All instructor communication must be conducted through Canvas conversations (https://umich.instructure.com/conversations#filter=type=inbox).

Select “Inbox” from the left menu bar, choose “MATSCIE 593-053 W 2024” from the course list, and in the “To:” field type Geeta Mehta, and my name will be easily available to message. Using Canvas Inbox is important for tagging each of your messages, and identifying them as course communication, to ensure that your messages aren't lost in our mailboxes.

Accommodations for Students with Disabilities:

If you think you need an accommodation for a disability, please let us know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way I teach may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, I can work with the Office of Services for Students with DisabilitiesLinks to an external site. (SSD) to help me determine appropriate accommodations. SSD (734-763-3000 or ssd.umich.edu) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. I will treat any information you provide as private and confidential.

Your success in this class is important to me. If you are not formally registered with Office of Services for Students with DisabilitiesLinks to an external site. (SSD) and have anxiety, depression, learning disabilities or any other issues that affect your ability to fully participate and learn in this class, you are encouraged to check-in with me so that I can best help you do well. Please set up a meeting with me via Canvas Inbox e-mail.

Inclusion and Diversity:

I aim to create an inclusive classroom where I value all students regardless of their background, country of origin, race, religion, ethnicity, disability status, gender, sexual orientation, etc. I am committed to providing a climate of excellence and inclusiveness within all aspects of the course. If there are aspects of your culture or identity that you would like to share with me, as they relate to your success in this class, I am happy to meet to discuss. Likewise, if you have any concerns in this area or are facing any special issues or challenges, you are encouraged to discuss this matter with me (set up a meeting via e-mail) with an assurance of full confidentiality (only exception being mandatory reporting of academic integrity/honor code violations and sexual harassment).

Student Mental Health and Well-being:

University of Michigan is committed to advancing the mental health and wellbeing of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, contact **Counseling and Psychological Services (CAPS)** at (734) 764-8312 and https://caps.umich.edu/Links to an external site. during and after hours, on weekends and holidays, or through its counselors physically located in schools on both North and Central Campus. You may also consult **University Health Service (UHS)** at (734) 764-8320 and https://www.uhs.umich.edu/mentalhealthsvcsLinks to an external site., or for alcohol or drug concerns, see www.uhs.umich.edu/aodresourcesLinks to an external

site.. For a listing of other mental health resources available on and off campus, visit: http://umich.edu/~mhealth/Links to an external site..

Normal levels of stress and anxiety are exacerbated by the continued uncertainties associated with the COVID-19 global pandemic. The College of Engineering has resources specifically designed to support students through this especially difficult time (https://care.engin.umich.edu/). Prof. Mehta is willing to contact the C.A.R.E center on behalf of any students (with their consent). Please don't hesitate to reach out!

Religious Observances

The University of Michigan, as an institution, does not observe religious holidays. However, I will make every reasonable effort to help students avoid negative academic consequences when their religious obligations conflict with academic requirements. If you find that an assignment due date conflicts with a religious observance, it is your obligation to let Prof. Mehta know at least 2 weeks in advance of the conflict. You will be given every opportunity to make up the work without penalty, unless it interferes unreasonably with course delivery. Please read the University of Michigan's full policy here: http://www.provost.umich.edu/calendar/religious_holidays18-19.html#conflictsLinks to an external site.

It is recommended that you review all other general University of Michigan College of Engineering policies, academic rules, information and more in the online bulletin, which can be found at https://bulletin.engin.umich.edu/Links to an external site.

Course structure and Expectations:

This is a graduate level course in Advanced Biomaterials that provides foundation on contemporary biomaterials principles. The overall objectives of this course include:

1. Provide graduate-level knowledge on biomaterials principles and applications
2. Introduction of biomimetic & rational design approaches to biomaterial engineering.
3. Understand fundamental principles of biomaterials surfaces and interfaces
4. Discuss the cellular and molecular aspects cell and tissue interactions with biomaterials.
5. Develop critical analysis and evaluation skills through literature review and proposal writing

The following assignments comprise the final scores and assess your understanding of the materials discussed in this course.

Mini-reviews:

Each student will be required to write 4 mini-reviews (one page). The goal of this assignment is to develop paper reading skills and provide experience with writing manuscript reviews.

It is expected that each student (as part of a group) will assist in leading one discussion during a specific class. Each group will sign up for a paper for the presentation of a specific assigned paper.

Final project (Market Research Plan):

Each student will participate in a group **Market Research Plan**. You will work as a team (3-4 students per group) to prepare the final project. Group assignments will be based on students' background and education level.

Each group will formulate and present an idea for a new start-up company that will develop a materials-based technology or therapy.

A 1/2 paragraph summary providing a general overview of the project is due on 8th March (tentatively), more than 6 weeks prior the final proposal. Each group will present their project proposal as a group to judges consisting of instructors, other faculty members and a student group. Critiques and a final score will be provided by the judges.

Final Market Research Plan reports should be no more than four pages long (not including references), Arial 11 font, single spaced and 0.5" margins. The reports must address the sections detailed below. Please include schematics and pictures to illustrate and outline your project.

Significance: Outline the healthcare problem that your project aims to address. Explain the clinical importance of the problem or existing barriers that your technology/therapy will solve.

Product overview: Provide an overview of the technology/therapy that you will develop. Explain how your product/therapy will change current clinical standards. Describe any new concepts, approaches or methodologies that you will develop or apply.

Innovation/Market analysis: Describe current technologies/therapies that compete with your idea. Explain the advantages of your idea over existing technologies/therapies (this may be from other companies or still in developmental stage).

Approach/aims: Detail the overall approach, methodology required to implement your technology/therapy. Include any research experiments, pre-clinical and clinical studies that will be needed.

Contingency plan: Describe the anticipated challenges and strategies how you will address these to bring your technology/therapy to the market.

References: Include references to relevant literature for all aspects of your proposal. Place your idea in the context of existing research and technologies/therapies.

The overall grading breakdown consists of the following:

Grading Criteria:

Participation (attendance; in-class discussions) 20%

Mini-reviews (4 written critiques of discussion papers) 25%

Paper Presentation (of 1 paper) 25% (group)

Market Research Plan (paragraph abstract, written draft Market Research Plan, Presentation, Final Market Research Plan) 30% (group)

Grading Breakdown for **Market Research Plan (group)** is shown below:

5% Paragraph Summary

45% Presentation in Class

45% Final Proposal

5% Peer Evaluations

References and Additional Reading:

- *Biomaterials Science: An Introduction to Materials in Medicine.* Wagner, W., Sakiyama-Elbert, S., Zhang, G., Yaszemski, M., (Editors) 4th Edition, Academic Press, 2020.
- *Advanced Materials and Manufacturing Techniques for Biomedical Applications*. Prasad, A., Kumar, A., Gupta, M., John Wiley and Sons. 2022.
- *Regenerative Medicine: Emerging Techniques to Translation Approaches*. Chakravorty, N., Shukla, P. C. (Editors), Springer Nature Singapore, 2023.
- *Advances in 3D bioprinting*. Narayan, R. (Editor), CRC Press, Taylor & Francis, 2024.

- *Hydrogels for tissue engineering and regenerative medicine: from fundamentals to applications.* Oliveira, J. M., Silva-Correia, J., Reis, R. L., (Editors), Academic Press, 2024.
- *Biomimetic biomaterials for tissue regeneration and drug delivery*, Dash, M., Springer, 2022.
- *Biomaterials: The Intersection of Biology and Materials Science,* Temenoff, J. S.; Mikos A. G.*,* Prentice Hall, New Jersey, 2008.
- *Principles of Tissue Engineering,* Lanza, R. P.; Langer, R.; Vacanti, J., (Editors) 2nd Ed., Academic Press, San Diego, 2000.
- *Biomaterials: An Introduction*, Park, J. B.; Lakes R. S.*,* 3rd Ed, Plenum Press, New York, 2007.
- *Synthetic Biodegradable Polymer Scaffolds*, Atala, A; Mooney, D. J. (Editors), Springer Verlag, New York, 1997.

Tentative Schedule for Winter 2024:

No	Date	Modules	Topic
1	01/10	1: Fundamentals	Overview and Introduction Final project instructions and examples
2	01/17		Final project instructions and examples Native tissue and cell sources
3	01/22		Concepts of biocompatibility and signaling
4	01/24	2: Biomimetic & Engineered Materials	Hydrogels I
5	01/29		Hydrogels II
6	01/31		Biomimetic materials I
7	02/05		Biomimetic materials II
8	02/07		Biofabrication

9	02/12		Surface characterization I **Mini-review 1 due on Feb 11th** **Paper discussion on 2024 Nature Comm, Bioinspired Structural Hydrogels**
10	02/14	3: Surfaces and interfaces	Surface characterization II
11	02/19		Protein adsorption
12	02/21		Biodegradation
13	03/04		Cell-Biomaterial interactions I **Mini-review 2 due on March 3rd** **Paper presentation on 2023 Nature, Cartilage Protein Entanglements**
14	03/06		Cell-Biomaterial interactions II **Mini-review 3 due on March 5th** **Paper discussion for 2023 Nature BME, Inflammation-induced Neovascularization**
15	03/11	4: Host reaction/Immune-response	Wound healing I
16	03/13		Wound healing II **Paragraph summary due on Market Research Project Plan** **Paper presentation on 2022 Nature Comm, Dynamic actuation**
17	03/18		Inflammation I
18	03/20		Inflammation II Immune responses guest lecture (Dr. Priyan Weerappuli)
19	03/25		Immune responses guest lecture (Dr. Priyan Weerappuli)
20	03/27		Immune response guest lecture (Dr. Priyan Weerappuli) **Mini-review 4 due on March 26th** **Paper discussion on 2023 Nature Comm, Tracing immune cells around biomaterials**

21	04/01		Immune modulation of biomaterials
22	04/03	5: Applications of Biomaterials	Drug delivery systems/Tissue engineered products/grafts
23	04/08		Clinical products in market **Market Research Project Report Draft proposal due**
24	04/10		Practical aspects and commercialization of biomaterials I
25	04/15	6: Final Presentations	Final Presentations
26	04/17		Final Presentations
27	04/22		Final Presentations
	04/28		**Final Market Research Project Plan and Final Presentation due**

Request for establishing permanent course number for 'Advanced Biomaterials'

The course has been offered during the following 3 semesters:

WN 2022 MATSCIE 593 – 076, Number of Students Enrolled – 34.

WN 2023 MATSCIE 593 – 076, Number of Students Enrolled – 12 and 5 Participants (not enrolled, from Dr. Marco Bottino's lab in Dental School).

WN 2024 MATSCIE 593 – 053, Number of Students Enrolled – 10. (includes 1 participant from Dr. Marco Bottino's lab in Dental School).

To be cross-list with: MATSCIE, BIOMEDE, MACRO, CHE

Course description:

Graduate-level course on contemporary concepts and applications in advanced biomaterials

'**Advanced Biomaterials'** is a graduate level course, created for learners who already have completed foundational studies on biomaterials. Biomaterials have important roles and growing impact on broad applications, including medical devices, implants, regenerative medicine, tissue engineering, sensors, diagnostics, and drug delivery. This graduate level course is designed primarily for graduate and senior undergraduate students in engineering or biological sciences, as a complement to the undergraduate course 'Design and Applications of Biomaterials' (BIOMEDE 410 or MATSCIE 410 or MACRO 410). This graduate course will cover contemporary concepts and applications in advanced biomaterials.

This course was taught as MATSCIE 593-076 in Winter 2022 and Winter 2023. The course was received well by the students during its past offerings. Therefore, I am requesting to make the '**Advanced Biomaterials'** course permanent in MATSCIE, BIOMEDE, CHE, and MACRO.

Course Evaluations in WN 2022 and WN 2023:

Course Evaluation for WN 2022:

University of Michigan
Winter 2022 Instructor Report With Comments
MATSCIE 593-076: MSE Special Topics
Geeta Mehta

30 out of 34 students responded to this evaluation.

Responses to University-wide questions about the course:

	SA	A	N	D	SD	N/A	Your Median	Univ-wide Median	School/College Median
This course advanced my understanding of the subject matter. (Q1631)	15	13	0	1	0	0	4.5	4.6	4.7
My interest in the subject has increased because of this course. (Q1632)	13	13	2	1	0	0	4.4	4.2	4.6
I knew what was expected of me in this course.(Q1633)	12	11	6	1	0	0	4.2	4.6	4.5
I had a strong desire to take this course.(Q4)	13	10	6	0	1	0	4.3	4.1	4.5
As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891)	1	6	21	1	0	1	3.1	3.0	3.0

Responses to University-wide questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median	Univ-wide Median	School/College Median
Geeta Mehta seemed well prepared for class meetings.(Q230)	15	11	4	0	0	0	4.5	4.8	4.8
Geeta Mehta explained material clearly.(Q199)	11	11	5	2	1	0	4.1	4.7	4.7
Geeta Mehta treated students with respect.(Q217)	29	1	0	0	0	0	5.0	4.8	4.9

Responses to questions about the course:

	SA	A	N	D	SD	N/A	Your Median
Overall, this was an excellent course. (Q1)	12	14	4	0	0	0	4.3

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Geeta Mehta was an excellent teacher. (Q2)	14	13	1	2	0	0	4.4

The medians are calculated from Winter 2022 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 16 to 74 in College of Engineering.

Course Evaluation for WN 2023:

University of Michigan
Winter 2023 Instructor Report
MATSCIE 593-076: MSE Special Topics
Geeta Mehta

12 out of 12 students responded to this evaluation.

Responses to University-wide questions about the course:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
This course advanced my understanding of the subject matter. (Q1631)	9	3	0	0	0	0	4.8	4.4	4.5
My interest in the subject has increased because of this course. (Q1632)	7	4	1	0	0	0	4.6	4.1	4.2
I knew what was expected of me in this course.(Q1633)	5	5	2	0	0	0	4.3	4.3	4.6
I had a strong desire to take this course.(Q4)	6	4	2	0	0	0	4.5	4.0	4.1
As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891)	1	6	5	0	0	0	3.7	2.8	3.0

Responses to University-wide questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median	School/College Median	Univ-Wide Median
Geeta Mehta seemed well prepared for class meetings.(Q230)	6	4	1	1	0	0	4.5	4.7	4.8
Geeta Mehta explained material clearly.(Q199)	6	4	1	0	1	0	4.5	4.6	4.7
Geeta Mehta treated students with respect.(Q217)	10	2	0	0	0	0	4.9	4.8	4.8

Responses to questions about the course:

	SA	A	N	D	SD	N/A	Your Median
Overall, this was an excellent course. (Q1)	8	4	0	0	0	0	4.8

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Geeta Mehta was an excellent teacher. (Q2)	7	3	1	0	1	0	4.6

The medians are calculated from Winter 2023 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 1 to 15 in College of Engineering.