UNIVERSITY OF MICHIGAN
College of Engineering
Curriculum Committee Meeting
Tuesday, October 1, 2024

Attending: Varun Agrawal, Achilleas Anastasopoulos, Sarah Barbrow, Yavuz Bozer, Xudong Fan, Chris Fidkowski, Anouck Girard, Vineet Kamat, Amir Kamil, Ryan Latimer, Xiaogan Liang, Frank Marsik, Radoslaw Michalowski, Nolgi Oquendo-Colon, Yulin Pan, Jeffrey Scruggs, Elyse Vigiletti, Won Sik Yang

Support Staff: Mercedes Carmona, Betsy Dodge, Matthew Faunce

Call to Order: 1:33 PM

Adjourned: 2:50 PM

Agenda:

1. Approval of 9.17.2024 Meeting Minutes – Page 3 - **APPROVED**
2. Proposal for CoE Grade Grievance Policy – Action Item – Page 8 – **APPROVED**
    a. After discussions with Kevin Pipe and faculty, a request was directed to the CoE Curriculum Committee to review the current CoE Grade Grievance Policy. The current CoE policy does not have specific deadlines or timelines, nor a process outlined for grade grievances.
        i. CEE says that LSA policy provides guidelines and information that should be included in the CoE policy for students, departments, staff, etc.
        ii. EECS – CSE states out that the LSA policy is too long. If CoE is to create a revised policy that our policy should be shortened and to only add deadlines, but not include as much information as LSA's policy.
        iii. IOE brings up why does the Dean need to be involved in a grade grievance. CoE Policy needs to be clear on who gets the final word for a grade dispute. Graduate Education agrees that there needs to be an outline of who is involved in the grade grievance process. Suggestion that this should be instructor, department chair, associate dean/dean.
            1. EECS -CSE says that we would want the Dean included so that the student is provided the opportunity to present their case. The CCC needs to reach out to the associate dean/dean if they would like to be involved in these conversations. LSA's policy states that nobody can override the instructor with the final grade grievance. Although the chair and/or dean can provide their opinion to the instructor, it is the instructor who gets the final say on the grade grievance for the student.
                a. IOE understands that a hearing to involve all within the department is reasonable, but CoE is a large college to involve the dean with these issues.
                b. Graduate Education suggests letting the dean be involved if a student is still not happy with the result of the grade grievance process as this may be a small number of cases, so rare for the dean to be involved.
                c. Later in email, CLaSP points out that the CoE Grade Grievance Policy states, "The final appeal at the College level is by petition to the Associate Dean for Undergraduate Education or the Associate Dean for Graduate and Professional Education."
        iv. EECS – ECE points out the Grade Grievance Committee listed in the LSA policy and is not in favor of creating another committee to oversee these issues. This needs to be listed in the CoE revised policy. IOE also agrees with this.
        v. TCHNCLCM agrees with adding deadlines, but there needs to be more context provided regarding the request to review the Coe Grade Grievance Policy to give an opinion.
    b. The CCC was asked to consider the following when reviewing the policy:
        i. Would the committee like to add deadlines to the current CoE policy?
            1. Majority vote from the committee agreed that the CoE Policy does need to include deadlines.

ii. What should the deadlines be (e.g., align with LSA)?
    1. The committee agreed that deadlines need to be outlined in a draft policy. A suggestion was given and agreed upon by the committee for a deadline of 30 days after the start of the next semester for a student to submit a grade grievance.
iii. Does the committee want the language to be as detailed as LSA's policies? Are there other issues that should be addressed?
    1. Majority vote from the committee agreed that the CoE Policy does not need to be as lengthy as LSA's, but to include all information needed for the student, department, staff, etc.
    2. The CCC Chair suggests keeping the policy revision as simple as possible given the current policy has not been brought to a meeting to be discussed until now.

c. A draft revision policy will be presented at a future CCC meeting. The committee will vote on the revised policy.

3. Proposal for CEE MSE Program Modifications for CE and EnvE – Action Item – Page 13 – **APPROVED**
    a. Modifications to 2 CEE MSE Programs:
        i. MSE Degree in Civil Engineering (CE) modifications
            1. Specialization Requirements – Instead of 12 credits, students are now required to take 6 credits of "specialization elective" coursework. Each specialization also has a list of "specialization prerequisites" that must be completed, without credit, if a student has not already completed similar coursework prior to matriculating.
            2. New Specialization Area – Hazards, Risk and Resilience (HRR), which reflects a growing area of strength among the faculty to provide to students to focus on.
            3. Math Cognate - The requirement of having students take one elective "math course" has been removed completely.
            4. CEE Cognate - The requirement to take one elective in an area outside their major concentration has been removed completely.
        ii. MSE Degree in Environmental Engineering (EnvE) modifications
            1. Core course requirements – Instead of 9 credits, students are now required to take 6 credits of core coursework in at least two of three areas provided This is designed to allow flexibility for the student's program of study. New areas are:
                a. C-Environmental Chemical Sciences
                b. B-Environmental Biological Sciences
                c. P-Environmental Physical Sciences
            2. Major concentration – There has been an update to the concentrations offered and revised completely for the degree. Changes in the field and availability of course offerings as well as keeping guidelines up to date. The new revised areas are:
                a. Environmental Process Engineering
                b. Energy, Climate, and Air Quality
                c. Environmental Data Systems and Finance
                d. Ecohydrology and Environmental Fluid Mechanics
            3. Math cognate – The requirement of having students take one elective "math course" has been removed completely.
            4. CEE cognate – The requirement to take one elective in an area outside their major concentration has been removed completely.
        iii. The effective term for these changes to occur is Fall 2025. All changes will be retroactively applicable to all students who matriculated in 2024.
    b. IOE questions the re-organizing of the courses in the new concentrations/specializations and to make sure a new course fits properly into the concentrations/specialization for the students.
        i. Department presenter states that the department is fully aware and engaged in creating new courses that will take into effect how to group the courses in the future. Counting courses for the proper concentration/specialization will not be overlooked and a top priority for the department.
    c. CoE CC members voted unanimously to approve this proposal. The proposal will appear at the December CoE Faculty meeting.

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
38	AEROSP	573	MOD	Change to Course Title, Abbreviated Title, and Course Description.	WT 2025	NO	YES	APPROVED		
41	AEROSP	586	NEW		FT 2025	NO	NO	APPROVED	Cross-listed with IOE 586.	
56	ECE	602	MOD	Change to Course Number.	FT 2025	NO	YES	APPROVED	Course change to ECE 567.	
59	ECE	995	MOD	Change to Enforced Prerequisite.	FT 2025	NO	YES	APPROVED		
62	IOE	567	NEW		WT 2025	NO	NO	APPROVED	Recommendation to make changes to Course Title.	
73	IOE	667	NEW		WT 2025	NO	NO	APPROVED	Recommendation to make changes to Course Title.	
84	NAVARCH	470	MOD	Change to Course Components.	FT 2025	NO	YES	TABLED	Cross-listed with MFG 470.	
87	NERS	250	MOD	Change to Enforced Prerequisite.	WT 2026	C	YES	TABLED		
90	NERS	311	MOD	Change to Advisory Prerequisite.	FT 2026	C	YES	TABLED		
93	NERS	441	MOD	Change to Enforced Prerequisite.	FT 2027	C	YES	TABLED		
96	NERS	484	MOD	Change to Enforced Prerequisite.	FT 2026	C	YES	TABLED	Cross-listed with BIOMEDE 484.	

UNIVERSITY OF MICHIGAN
College of Engineering
Curriculum Committee Meeting
Tuesday, September 17, 2024

Attending: Varun Agrawal, Achilleas Anastasopoulos, Scott Baalrud, Yavuz Bozer, Alexander Burgers, Xudong Fan, Chris Fidkowski, Anouck Girard, Saadet Albayrak Guralp, Vineet Kamat, Amir Kamil, Brian Kiedrowski, Leena Lalwani, Ryan Latimer, Xiaogan Liang, Frank Marsik, Radoslaw Michalowski, Nolgi Oquendo-Colon, Kevin Pipe, Elyse Vigiletti, Won Sik Yang

Support Staff: Mercedes Carmona, Matthew Faunce

Call to Order: 1:32 PM

Adjourned: 2:56 PM

Agenda:

1. Presentation by Kevin Pipe, Associate Dean of Undergraduate Education
    a. CoE Curriculum Committee members need to attend meetings for each CoE department to have representation. Engagement seems to be lacking due to not attending meetings, not knowing a CARF is to be presented and what the CARF changes are, not reviewing meeting minutes/agendas, and HLC audit responsibilities. While we understand this is challenging due to teaching and other department responsibilities, the CoE Curriculum Committee is one of the only committees to have representation for all departments, so this is important to remember and actively attend and engage in meetings.
        i. IOE representative states most challenges come from faculty waiting too long for CARFs/proposals even with telling departments of deadline dates for the CoE CC and University Registrar Office. Also, reminds department that these committees and/or offices only meet so often to review the items needed for the department and that items cannot be reviewed and approved quickly.
        ii. Robotics mentions there are other topics to be discussed that affect undergraduate students and the change in engineering due to AI and COVID rather than the time spent on CARFs and proposals. More participation would occur if more important topics were to be discussed.
            1. Kevin says to form and/or join subcommittees that address the type of topics that need to be covered. The CoE CC is intended for CARFs, proposals, and/or other topics that relate to CoE overall.
            2. CoE CC Chair mentioned that on the 9.3.2024 CoE CC meeting that these topics were discussed for big picture issues, such as the change to Common Degree requirements.
                a. Kevin states that there is a First-Year program committee forming to look at requirements and/or other issues/topics to be discussed. Working with this new committee and the CoE CC could be something that happens in the future due to the ongoing topics, such as online learning and what this should look like in the future for CoE.
    b. Any CoE CC member is more than welcome to reach out to Kevin to discuss any issues/topics as needed.
2. Approval of 9.3.2024 Meeting Minutes – Page 4 - **APPROVED**
3. Proposal for CoE Grade Grievance Policy – Information Item – Page 7 – **TABLED**
    a. This item will be pushed to the next CoE CC Meeting on 10.1.2024. Members are to review the policies and information given in the document to be prepared to go over in the next meeting.
4. Proposal for ECE Graduate Major Modification – Action Item – Page 12 - **APPROVED**

a. New graduate major area in Quantum Engineering, Science, and Technology (QUEST) within the Electrical Computer Engineering division of the EECS Department with an effective term of Fall 2025. Quantum technology is growing rapidly, so establishing quantum engineering as a focused graduate area of study is putting Michigan Engineering as a leader in this field. Available for both Master's and PhD students to take, but only will appear on a Master's student transcript and not for a PhD student. The major requirement is that students must take 9 credits in the major area with 6 credits needing to be 500+ level courses.
b. Question as to what are the other existing major areas for ECE?
    i. Just to name a few are Power and Energy, Optics & Photonics, Integrated Circuits & VLSI, Embedded Systems, Computer Vision. The Bulletin and Department websites contain all information for major areas for ECE Graduate students.
c. CoE CC members voted unanimously to approve this proposal. The proposal will appear at the December CoE Faculty meeting.

5. Proposal for IOE BSE Program Modification – Action Item – Page 18 - **APPROVED**
    a. ROB 101 as a substitute for the existing linear algebra requirement for students majoring in IOE effective for Fall 2025. 3 unique points this will benefit IOE students:
        i. First-year students do not need prerequisite knowledge of calculus. Allows for an accelerated trajectory to take higher-level IOE courses compared to the complete of MATH 214 for the calculus sequence.
        ii. ROB 101 mirrors MATH 214, but also includes written problem sets for theoretical comprehension as well as integrating programming assignments along with linear algebra concepts to real world computational problems.
        iii. ROB 101 introduces linear algebra with an engineering focus needed for IOE students, such as computation and robotics.
    b. CEE department mentions if there would be any ABET implications due to a 200-level course being replaced by a 100-level course.
    c. TCHNCLCM asks if the CoE CC is to encourage modifications such as this and if not then whose role would that be?
        i. CoE CC Chair states that any changes to program requirements for linear algebra and/or any other changes should come through the CoE CC for review and approval.
            1. Robotics states that the department is fully onboard with IOE making this program modification for IOE students.
    d. MECHENG states that the department is pilot testing for students to take an engineering course to substitute MATH 216. Should the department be making a proposal for this change already?
        i. CoE CC Chair says that exceptions are fine in this case as this is early and still testing out for MECHENG students. If the department is to expect this change to be long term for MECHENG students and alter MECHENG degree requirements, then a proposal would need to be reviewed at a CoE CC meeting.
    e. CoE CC Chair brings up that further discussions need to be had with either this committee and/or subcommittees regarding the math requirements for CoE students as students do not enjoy taking UM math courses and more students are taking these courses externally to transfer credit.
    f. CoE CC members voted unanimously to approve this proposal. The proposal will appear at the December CoE Faculty meeting.

6. Proposal for NERS BSE Program Modification – Action Item – Page 30 – **APPROVED**
    a. Effective for Fall 2025, NERS is making changes to their BSE degree by:
        i. MATH 216 to be removed from the CoE Common Degree requirements and replaced with NERS 320 for NERS BSE students.
        ii. With the moving of NERS 320 from the NERS Program Subjects requirements, NERS 420 is a new course that will replace NERS 320.
    b. The department's reasoning for these changes:
        i. MATH 216 is not meeting the needs for NERS majors.
        ii. The NERS Department would like to cover more topics which currently do not fit in the curriculum.
        iii. NERS 420 will fill a need for an expanded mathematics curriculum for many incoming graduate students.
    c. IOE brings up concern with increasing the workload for departments by creating a course within a department.
        i. NERS department weighed the pros and cons and ultimately it was best to invest in the students as this course will be beneficial in the long run to cover the topics NERS students need.
        ii. EECS-ECE mentions how does the math department feel regarding CoE departments creating courses that are substitutes for math courses. Should we be reaching out to the math department to go over the curriculum/topics covered that are missing for engineering students?

1. COE CC Chair brings up that MATH 214 was created for engineering and still does not cover the topics needed for engineering students. Conversations should be had between CoE departments and the math department as needed.
2. For example, the Robotics department has been in conversations and worked with the math department for ROB courses to be taken instead of math courses and the math department was amenable.

d. CoE CC members voted unanimously to approve this proposal. The proposal will appear at the December CoE Faculty meeting.

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
33	BIOMEDE	517	MOD	Change in Course Description, Full Term Credit Hours, Course Credit Type, and Course Components. Adding a new Cross-Listing with ROB 517.	WT 2025	B	YES	CONDITIONAL APPROVAL	Recommended change to the Abbreviated Title to reflect the Course Title.	
36	EECS	415	NEW		WT 2025	NO	NO	APPROVED		
48	IOE	461	MOD	Change in Abbreviated Title, Course Description, Advisory Prerequisite, and Credit Exclusions.	WT 2025	C-	YES	CONDITIONAL APPROVAL	Cross-listed with MFG 461. Change Page 3 Course Description – Requested Listing Side to reflect the change on Page 1.	
51	IOE	465	MOD	Change in Course Description, Advisory Prerequisite, and Credit Exclusions.	WT 2025	C-	YES	APPROVED		
54	IOE	466	MOD	Change in Course Description and Credit Exclusions.	WT 2025	C-	YES	APPROVED	Cross-listed with MFG 466.	
57	KINESLGY	533	MOD	Change in Course Subject.	WT 2025	NO	YES	APPROVED	Cross-listed with BIOMEDE 533.	
60	NAVARCH	470	MOD	Change in Course Components.	WT 2025	NO	YES	TABLED – No member to present	Cross-listed with MFG 470.	
63	NERS	320	MOD	Change in Course Title, Abbreviated Title, Course Description, Enforced Prerequisite, and Terms Typically Offered.	WT 2026	C	YES	CONDITIONAL APPROVAL	Change Abbreviated Title to include engineering, such as “App Math Eng Phys I”.	
66	NERS	420	NEW		FT 2026	C	NO	CONDITIONAL APPROVAL	Change Abbreviated Title to include engineering, such as “App Math Eng Phys II”.	
75	NERS	471	MOD	Change in Course Description and Advisory Prerequisite. Adding a new Cross-Listing with EECS 415.	WT 2025	NO	YES	APPROVED		

87	**STATS**	**570**	**MOD**	Change in Home Department, Abbreviated Title, Course Description, Full Term Credit Hours, Course Credit Type, and Advisory Prerequisite.	**WT 2025**	**NO**	**YES**	**CONDITIONAL APPROVAL**	Cross-listed with IOE 570. Cross-listing checkbox needs to be checked with STATS 570 to be listed on the Requested Listing Side.	

CoE Grade Grievance Policy Proposal

Per a request from Kevin Pipe, following a discussion with faculty, he requested that the CoE Curriculum Committee review our current Grade Grievance Policy and possibly consider aligning with LSA's policy that includes deadlines (in bold under the LSA's Policy section), if needed.

For the CCC consideration:

1. Would the committee like to add deadlines to our current policy?
2. What should the deadlines be (e.g., align with LSA)?
3. Does the committee want the language to be as detailed as LSA's policies (see below)? Are there other issues that should be addressed?
4. We can bring back a final draft for the committee to vote upon at the next meeting.

CoE's Current Policy in the Online CoE Bulletin:

Grade Grievances Procedure

If there is justification to question the accuracy of an assigned grade, the student should first pursue the matter with the instructor. The responsibility for the assignment of grades is primarily that of the instructor and should be settled between the student and instructor whenever possible. Further pursuit of a grade grievance should be addressed with the instructor's Department Chair. The final appeal at the College level is by petition to the Associate Dean for Undergraduate Education or the Associate Dean for Graduate and Professional Education.

Student Grievances

The College of Engineering has a grievance procedure to address student complaints.

Undergraduate and graduate students should follow these steps until a resolution is achieved:

1. Attempt to resolve the grievance directly with the individual involved (faculty member, staff member, or fellow student).
2. If the matter is unresolved, and the grievance is with a faculty member or teaching assistant, discuss the grievance with the appropriate Department Chair.
3. If the issue is still unresolved, undergraduate students should see the Associate Dean for Undergraduate Education and graduate students should see the Associate Dean for Graduate and Professional Education who are both located in the Robert H. Lurie Engineering Center.

4. All students have the right to appeal to the Dean of the College if they feel their grievances have not been resolved satisfactorily by another dean.

LSA's Current Policies from their LSA Academic Policies website:

Grade Grievance

Grade Change Policy

"A grade change may be submitted by your instructor to correct an error on a Supplementary Grade Report which the instructor obtains from their department office. The request must be accompanied by a formal explanation by the faculty member in charge of the course outlining the circumstances surrounding the original error and justifying the grade change." (Faculty Code B5.07)

LSA Student Records cannot approve any Supplementary Grade Report for a grade change when "extra work is submitted," "student rewrote a paper," "student retook the final," or another special arrangement unless the instructor is able to provide a statement that the arrangement giving this one student the opportunity to raise his/her grade was an arrangement available to and known by every student in the course. If the grade is being changed because the work was submitted after grades were due and no "incomplete" grade was originally given, the grade will be posted with and "I" as long as the work was completed during the incomplete deadline period.

When the instructor is changing a grade from "incomplete", they must include the date the student submitted their completed work. Even if the course has lapsed to E the grade can still be approved for posting if the work completed by the student was within the incomplete deadline date or the extended deadline date.

Grade Grievance Procedures

Introduction

Instructors are expected to set fair and consistent grading procedures for their respective courses. The following policy provides students a means to contest a final course grade received in a credit-bearing course if a student believes fair and consistent grading procedures have not been followed. A final grade is only subject to review when 1) a procedural error has been discovered in the calculation or recording of a grade, or 2) there is a concern that the grade was not fairly given. Disagreeing with grading policies or an instructor's assessment of work is not a basis for a grade grievance.

Occasionally, the basis of a student's grade grievance is that the student was subjected to harassment or discrimination. It is not the function of the Grade Grievance process to evaluate claims of discrimination or harassment. Please contact the Office of Diversity, Equity & Inclusion (ODEI), and the Associate Chair of Undergraduate Studies (ACUS) or Director of Undergraduate Studies (DUS) in the department in question will evaluate whether the grade grievance should be paused until the OIE matter is resolved.

The steps for the grade grievance process are outlined below:

Step 1: Seek Resolution with the Instructor

As the first step in the grade grievance process, the student should inquire about the accuracy of their final grade to the lead instructor of the course. This initial inquiry should take place **within the first 15 university business days** of the beginning of the following winter term for courses taken during the fall semester, and **within the first 15 university business days** of the beginning of the following fall semester for courses taken during the winter, spring, or summer sessions. In the case of an incomplete or a grade that is submitted after the start of the next full term, the initial inquiry should take place within the first 15 university business days after the official posting of the grade.

If, after this inquiry, the student is not satisfied with the instructor's response, the student may choose to initiate a formal grade grievance. If the lead instructor has left the University, is on approved leave, or does not respond to the student after a reasonable effort (within 10 business days), the student may also proceed directly to Step 2 and initiate a formal grade grievance.

Step 2: Submit a Formal Grade Grievance

To begin the formal grade grievance process the student must submit to the Associate Chair of Undergraduate Studies (ACUS) or Director of Undergraduate Studies (DUS) [refer to the LSA Grade Grievance Department Contact list] a written statement that includes the following information:

- the basis for the allegation of arbitrary grading, including specific evidence (e.g. course syllabus, graded work) that supports the allegation
- a summary of the outcome of the initial inquiry to the course instructor, indicating what aspects are in dispute and any documentation to support the initial inquiry with the instructor
- the desired outcome for the grievance

This written statement must be submitted **within the first 30 university business days** of the beginning of the following winter term for courses taken during the fall semester, and **within the first 30 university business days** of the beginning of the following fall semester for courses taken during the winter, spring, or summer sessions. In the case of an incomplete or a grade that is submitted after the start of the next full term, the written statement must be submitted within the first 30 university business days after the official posting of the grade.

If any of the above deadlines are not met by the student, the grievance will be considered invalid and closed, unless, due to extenuating circumstances, the office of the LSA Assistant Dean of Undergraduate Education and Student Academic Affairs grants an extension of time. If you believe there was an extenuating circumstance (i.e. hospitalization, extended leave from health reasons) please contact the LSA Office of Student Academic Affairs (lsa.saa.office@umich.edu) for more information.

Upon receipt of the written complaint in Step 2, the ACUS/DUS will notify the office of the LSA Assistant Dean of Undergraduate Education and Student Academic Affairs of the complaint within 5 business days of receipt of the complaint. The ACUS/DUS will then ask the instructor to provide a written summary explaining how the final grade was determined and responding to the specific claims made by the student. After receiving the response from the instructor, the ACUS/DUS will determine if sufficient evidence exists to convene the Department's Grade Grievance Committee. If the ACUS/DUS determines that there is insufficient evidence for the grade grievance, the matter is considered closed, and the original grade stands. The ACUS/DUS will communicate this in writing to the student **within 15 university business days** from receipt of the complaint. A copy of the response should also be sent to the office of the LSA Office of Student Academic Affairs at the same time.

Step 3: Formal Grade Grievance Hearing

If the ACUS/DUS determines that the grade grievance should proceed, an appropriate Departmental Grade Grievance Committee will be selected, and a date for a formal hearing with the Grade Grievance Committee will be set. The hearing should occur no more than 60 days after submission of the complaint. All parties (student, instructor, and committee) will be provided with copies of the written student complaint and the instructor's summary in advance of the formal hearing. During the formal hearing, the student will be asked to first present the basis of their complaint; the instructor will then be asked to present their explanation for how grades were determined. Following an open period of questions to all parties, the formal hearing will be adjourned.

The Grade Grievance Committee will then have **ten university business days** to determine its recommendation and submit a written report to the ACUS/DUS.

- If the Grade Grievance Committee decides that a grade change is not warranted, the ACUS/DUS will convey this in writing to the student and the instructor. The original grade will stand and the matter is considered closed.
- If the committee recommends a grade change, the ACUS/DUS will communicate that decision directly to the instructor. The instructor will then be asked to respond in writing within five university business days to the ACUS/DUS indicating whether or not they will abide by the Grade Grievance Committee's recommendation.
    - If the instructor agrees to a grade change, the ACUS/DUS will in writing inform the student of the instructor's decision and the student's final course grade will be changed. The matter is considered closed.
    - If an instructor does not accept the Grade Grievance Committee's recommendation to change the final grade, the original grade will stand. A final course grade rests solely with the instructor and, as such, a course grade cannot be changed without the instructor's consent. When this occurs, the ACUS/DUS will convey in writing this decision to the student. The matter is considered closed. There is no appeal beyond the Department.
- A report stating what procedures were followed and what decision was reached will be sent to the office of the LSA Office of Student Academic Affairs by the ACUS/DUS **within 5 business days** after the conclusion of the review process.

COLLEGE OF ENGINEERING
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To: Members of the College of Engineering Curriculum Committee

From: Jeff Scruggs, Ph.D., Professor, Civil & Environmental Engineering
Masters Chair

Date: September 10, 2024

Subject: Changes to guidelines for:
MSE in Civil Engineering
MSE in Environmental Engineering

The Department of Civil and Environmental Engineering (CEE) has recently drafted new guidelines for our MSE degree in Civil Engineering (CE), as well as our MSE degree in Environmental Engineering (EnvE). In the EnvE case, the changes reflect a shift in the course offerings in the department, the interests of students, and changes in the profession. In the CE case, the changes are motivated by the same issues, together with the need to simplify and streamline the MSE requirements. The revised guidelines for both degrees are attached.

The purpose of this memo is to highlight these changes, and to request the approval of the CoE Curriculum Committee.

Summary of changes to the MSE in EnvE

1. *Core course requirement*: The old guidelines required all students to take 9 credits of core coursework: CEE 581 (Aquatic Chemistry), CEE 582 (Environmental Microbiology), and CEE 591 (Environmental Fluid Mechanics). The new guidelines require all students to take 6 credits of core coursework in at least two of three areas: Environmental Chemical Sciences (C), Environmental Biological Sciences (B), and Environmental Physical Sciences (P). For each area, core requirements can be satisfied by one of the courses below:
   C: CEE 581, CEE 597
   B: CEE 582, CEE 693
   P: CEE 591, CEE 590, CEE 521
2. *Major concentration*: The old guidelines required all students to take 12 credits in one major area of concentration. Each major area had a list of approved courses, and students could also obtain approval to take courses not on the pre-approved list to satisfy the requirement. The areas were:
   Ecohydrologic Systems
   Sustainable Energy Systems
   Water Quality Process Engineering
   Water Quality Resources and Engineering
   The new guidelines have revised these four major areas, together with the list of pre-approved courses. The revised areas are:
   Environmental Process Engineering
   Energy, Climate, and Air Quality
   Environmental Data Systems and Finance
   Ecohydrology and Environmental Fluid Mechanics
3. *Math cognate*: The old guidelines required students to take one elective of "math cognate" coursework from a pre-approved list of courses involving advanced mathematics. Students were given leeway to obtain approval to use courses not on the pre-approved list to satisfy the requirement, as appropriate. The new guidelines do away with the math cognate requirement.
4. *CEE cognate*: In the old guidelines, students were required to take one elective in an area outside their major concentration, either within the CEE department or outside of it. The new guidelines do away with this explicit requirement.

Summary of changes to the MSE in CE

Historically, the MSE program in CE allows students to specialize in their choice of subdiscipline, including Construction Engineering and Management, Geotechnical Engineering, Hydraulic Engineering, Intelligent Systems, Materials Engineering, Structural Engineering, and Transportation Engineering. Each of these areas provided its own guidelines document to students, to aid them in planning their program of study. Students could also propose their own customized program of study, subject to the approval of the Masters Chair. The new, revised guidelines constitute a unified document that puts all these specializations into a common framework of requirements. Substantively, the actual changes to the requirements of each specialization are minimal.

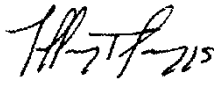
1. *Specialization requirements*: All specializations now require students to take 12 credits of "specialization core" coursework, from a pre-approved list. These courses cover foundational aspects of the specialization. Students are also required to take 6 credits of "specialization elective" coursework, covering topics that not as foundational but also strongly relevant to the specialization. Each specialization also has a list of "specialization prerequisites" that must be completed, without credit, if a student has not already completed similar coursework prior to matriculating.
2. *New specialization area:* In addition to the existing specialization areas, a new specialization has been created in the area of Hazards, Risk and Resilience (HRR). This reflects a growing area of strength among the faculty in this area, and a growing set of coursework that students can take which focuses on it.
3. *Math cognate*: The old guidelines required students to take one elective of "math cognate" coursework from a pre-approved list of courses involving advanced mathematics. Students were given leeway to obtain approval to use courses not on the pre-approved list to satisfy the requirement, as appropriate. The new guidelines do away with the math cognate requirement.
4. *CEE cognate*: In the old guidelines, students were required to take one elective in an area outside their major concentration, either within the CEE department our outside of it. The new guidelines do away with this explicit requirement.

Historically, the specializations in the CE degree were not "official" concentrations, as deemed by the CoE and Rackham. They do not show up on a student's transcript, and there was nothing in MSE guidelines for the CE degree that stated that a specialization must be chosen. We would like to elevate the specializations to officially be Concentrations, which appear on their transcript.

Implementation and Timeline

We intend to transition to the new guidelines, exclusively, in the Fall 2025 semester.

However, in both the EnvE and CE cases, the new guidelines are backward-compatible, meaning that with only a few minor exceptions, any program of study that satisfies the old guidelines also satisfies the new. The new guidelines provide students with more choices and flexibility. Because of this, we would like to give students the option to follow the new guidelines as soon as possible, and would like them to be retroactively applicable to all students who matriculated in 2024. Given the backward-compatibility, we do not anticipate any problem with this implementation plan.



Jeff Scruggs
Professor & Masters Chair
Department of Civil & Environmental Engineering

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 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 ● CEE 571: Linear System Theory	● CEE554: Data Mining in Transportation ● 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

Natural Hazards, Risk, and Resilience Faculty Advisor: S. Guikema		
Prerequisites	Specialization Core	Specialization Elective
• CEE 373: Probability and Statistical Methods	• CEE 501: Modeling Regional Disaster Impacts • IOE 561: Risk Analysis • CEE 554: Data Mining in Transportation • CEE 501: Spatial Data Analytics • EAS 567: Social Vulnerability and Adaptation to Environmental Change	• CEE 548. Geotechnical Earthquake Engineering • CEE 553. Infrastructure Systems Optimization • CEE 573. Data Analysis in Civil and Environmental Engineering • IOE 574: Simulation Modeling • CEE 611: Performance- Based Earthquake Engineering • CEE 576 (MECHENG 549). Stochastic Systems • CEE527: Floods, Tsunamis, Hurricanes • CEE421: Hydrology and Floodplain Hydraulics • CEE 517: Structural Reliability

Suggested General Electives

The following courses are commonly taken by CE students specializing in Natural Hazards, Risk, and Resilience:

- CEE 567. (ESENG 567) Energy Infrastructure Systems
- CEE 568: Water and Sanitation (WASH) Design and Practice
- EARTH 408: Introduction to GIS in Earth Sciences
- EAS 531: Principles of GIS
- EAS 541: Remote Sensing
- EAS 635.001 - Multivariate Stats
- SI 536/URP 353: Introduction to Urban Informatics
- SI 537: Crisis Informatics
- CEE 575. Sensing for Civil Infrastructure Systems
- CEE 526. Design of Hydraulic Systems
- CEE 546. Slopes, Dams, and Retaining Structures
- CEE 575. Sensors, Data, and Automation
- EAS 541: Remote Sensing of Environment
- TCHNCLCM 610: Technical and Professional Communication For Graduate Students
- EARTH 526: Earthquake Hazard and Fault Mechanics
- SI 501: Contextual Inquiry and Consulting Foundations
- SI 547: Engaging with Communities (NOTE: SI 501 is a prerequisite)
- CEE 504. Engineering Economics and Finance
- CEE 520. Physical Processes of Land-Surface Hydrology
- CEE 521. Flow in Open Channels
- CLIMATE 530. Using Climate-Change Knowledge in Planning and Design
- CLIMATE 588. Regional Scale Climate
- CLIMATE 591. Climate Practicum I
- CLIMATE 592. Climate Practicum II

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
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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: _____

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: 2024-09-19
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): Aerospace Engineering Subject: AEROSP Catalog: 573	Dept (Home): Aerospace Engineering Subject: AEROSP Catalog: 573
☐	☐ 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) Dynamics and Control of Spacecraft	Course Title (full title) Spacecraft Attitude Dynamics and Control
☑	Abbreviated Title (20 char) Dyn&Control SC	Abbreviated Title (20 char) SC Attitude Dyn&Ctrl
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Introduction to spacecraft attitude dynamics and control. Topics include attitude representations; dynamics and stability of rigid spacecraft with momentum wheels; deterministic and stochastic attitude estimation; and attitude control of spacecraft using internal and external torques. Focus on underlying mechanics with coverage of typical spacecraft attitude sensors and actuators.	
☐	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: Aerospace Engineering Catalog: 573

☐

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) AEROSP 470 or graduate standing	Advisory Prerequisite (254 char) AEROSP 470 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: Ilya Kolmanovsky Cognizant Faculty Member Title:

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

Contact Person: Email: Phone:

CoE Curriculum Committee Representative: Krzysztof Fidkowski Print: Krzysztof Fidkowski Date: 9/19/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Carlos Cesnik Print: Carlos Cesnik Date: 9/19/2024

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 Introduction to spacecraft dynamics and control. Spacecraft orbit and attitude representations, kinematics, dynamics. Perturbation equations for near circular orbits. Spacecraft maneuvers formulated and solved as control problems.	Course Description Introduction to spacecraft attitude dynamics and control. Topics include attitude representations; dynamics and stability of rigid spacecraft with momentum wheels; deterministic and stochastic attitude estimation; and attitude control of spacecraft using internal and external torques. Focus on underlying mechanics with coverage of typical spacecraft attitude sensors and actuators.
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:
Technical Elective

Special resources of facilities required for this course:

Supporting statement:
The course description and title are being changed for clarity

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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: 2024-03-22
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): Subject: Catalog:	Dept (Home): Aerospace Engineering Subject: AEROSP Catalog: 586
☑	☐ Course is Cross-Listed with Other Departments	☑ Course is Cross-Listed with Other Departments
	Department / Subject / Catalog Number	Department / Subject / Catalog Number
		Industrial and Operations Engineering - IOE - 586
☑	Course Title (full title)	Course Title (full title) Air Transportation Systems
☑	Abbreviated Title (20 char)	Abbreviated Title (20 char) Air Transp Systems
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Overview of air transportation systems; course splits into four modules: Airlines, airports, airspace, and emerging topics. Topics include airline schedule development, fleet/crew assignment, airline revenue management; airport capacity and planning, tactical/strategic demand management; air traffic control, deterministic/stochastic air traffic flow management; drone traffic management and air-space integration.	
☑	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)
☐	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: Max Li	Cognizant Faculty Member Title:

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

Contact Person: Email: Phone:

CoE Curriculum Committee Representative:	Krzysztof Fidkowski	Print: Krzysztof Fidkowski	Date: 9/18/2024
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:	Carlos Cesnik	Print: Carlos Cesnik	Date: 9/18/2024
Cross-Listed Department Chair:	Julie E. Ivy	Print: Julie Simmons Ivy	Date: 09/19/24
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description	Course Description Overview of air transportation systems; course splits into four modules: Airlines, airports, airspace, and emerging topics. Topics include airline schedule development, fleet/crew assignment, airline revenue management; airport capacity and planning, tactical/strategic demand management; air traffic control, deterministic/stochastic air traffic flow management; drone traffic management and air-space integration.
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:
This is a 500 level elective for grad student curriculum.

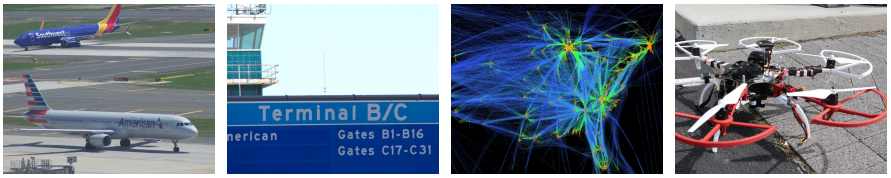
Special resources of facilities required for this course:

Supporting statement:
This graduate-level course provides a rigorous overview of the air transportation system with an emphasis on operations research and systems engineering. Examples of IOE-relevant methods that are covered in the course include large-scale integer programming (e.g., airline fleet/tail assignments, crew assignment, airport ground holding optimization, air traffic flow management), as well as stochastic/dynamic augmentations. In particular, this course showcases a complex, modern logistics system that serves as an excellent example of how operations research and operations management can be applied in the real world.

AEROSP 740
Air Transportation Systems

Fall 2023
Tues/Thurs 4:30-6, G906 COOL

Instructor:	Max Z. Li, 3029 FXB	**Time:**	TR 4:30-6
Email:	maxzli@umich.edu	**Place:**	G906 COOL
Office Hours:	T 3:30-4:20, 3029 FXB		
Syllabus Updated:	February 6, 2024		



All images taken/generated by Max Z. Li

Course Description: The air transportation system is a canonical example of a capacity-constrained, societal-scale infrastructure; it couples a cyber-physical network with a socio-technical one, with an overarching goal of safe and efficient movement of people and goods through the skies. In this course, students will be given a technical introduction to and overview of the critical components comprising the air transportation system.

This course is organized into four modules: (1) Airlines – topics include airline business models, schedule development, fleet/crew assignment models, airline revenue management, as well as flight dispatching and irregular operations; (2) Airports – topics include airport capacity and planning, taxiway and runway design, tactical and strategic demand management, and passenger terminal buildings; (3) Airspace system – topics include air traffic control, deterministic and stochastic air traffic flow management, Collaborative Decision-Making, and air navigation service provider initiatives such as FAA NextGen and Eurocontrol SESAR; (4) Other and emerging users – topics include air cargo operations, drones/UAS, Advanced Aerial Mobility (AAM), and UAS traffic management (UTM). Other advanced topics related to air transportation systems may be covered, depending on student interest.

Audience: Given the inherently interdisciplinary perspectives in air transportation, this course may be of interest to students in Aero, IOE, CEE, as well as city/urban planning (Taubman) and business (Ross), who are interested in learning about a fascinating transportation system, and/or applications of methods found in operations research, network science, statistics, and economics.

Prerequisites: Optimization (e.g., IOE 310, IOE 410), linear algebra (e.g., MATH 217), and familiarity with a programming language such as MATLAB, Python, R/RStudio will all be helpful; or permission of the instructor.

Statement of Values: I sincerely and emphatically believe that the true richness and impact potential of a person's contributions can be best realized in the following dual setting: (1) When the person feels supported mentally, emotionally, academically, and their lived experiences are embraced without prejudice; (2) When the person is surrounded by others who not only come from different backgrounds, experiences, and identities, but also share the same set of commitments towards diversity, inclusion, and equity.

Course Calendar (*subject to change*): See Google Sheet. Please be sure that you are looking at the class schedule for AEROSP 740 (and *not* AEROSP 350).
NB: Lectures are organized by modules, with Airlines [AL], Airports [AP], Airspace system [AS], and Other/emerging users [AO]. There will also be special guest lectures!

Assessments and Grading: Students will be assessed based on 4 problem sets, a final project, and class participation/engagement.

- Each problem set, to be completed individually, corresponds to a course module (Airlines; Airports; Airspace system; Other and emerging users), and consists of several questions, along with a literature review component.
- The final project, to be completed individually or in pairs, can be either (1) a synthesis/review of the current state of practice for a topic relevant to air transportation systems, or (2) a research project in terms of methods and applications pertinent to air transportation systems – more detail on the final project will be given in class.
- The grading breakdown is as follows:
  - Class participation and engagement (**10**%)
  - Four (4) **problem sets** ($4 \times 12.5\% = \mathbf{50}\%$)
  - **Final project**: Proposal + check-in milestone + final presentation + final write-up ($5\% + 5\% + 15\% + 15\% = \mathbf{40}\%$)
- Nominally, late deliverables will be penalized 10% per day late. Open, honest, and transparent communications are *essential!* please reach out if you have extenuating circumstances with respect to deliverable due dates.

Honor Code and Collaboration Policy: In this course, collaboration and discussion are strongly encouraged; at the same time, we stand by the core values of engineering. Per the University of Michigan College of Engineering Strategic Vision Values & Honor Code:

(i) explicitly crediting any collaborators,

(ii) forbidding the appropriation of derivations, code, data, plots, or writing across students, even with modifications or paraphrasing.

The use of solutions from other source (such as web resources) is not allowed and will represent a breach of the honor code rules for this course. All in all, any writing included in an assignment must be authored by you (or your team, for the final project deliverables); this similarly applies to any derivations, data or plots.

Student Mental Health: Stress and anxiety are more common than the national average among undergraduate and graduate students. These environmental stressors, combined with past and current personal circumstances, can severely affect a student's academic performance and their quality of life in general. I encourage you to be supportive of your classmates as you share this learning experience. The Department, the University, and I are committed to advancing your mental health and well-being.

Wellness Resources:

- Academic, financial, and wellness support: CARE center,
- Psychiatric Emergency Services (734-996-4747),
- Services for Students with Disabilities (734-763-3000; 734-615-4461 [TDD]; 734-619-6661 [VP]; ssdoffice@umich.edu),

- Free Aero tutoring (SGT, sgt-academic@umich.edu),
- Diversity, equity, and inclusion resources.

I invite you to reach out to me (maxzli@umich.edu) to talk about any of the above issues that concern you. I am available for individual meetings outside regular class and office hours.

Tech Resources:

- Network and computer support: CAEN, Aero Tech Center (David McLean, dmclean@umich.edu),
- Laptop loaner program.

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. I understand that sexual violence can undermine students' academic success. I encourage anyone dealing with sexual misconduct to talk to someone about their experience, so 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 non-confidentially reported to the Office for Institutional Equity (OIE) at https://oie.umich.edu/.

Student Accommodations: I am committed to building an accessible learning environment that fosters the academic success of all students. I aim to abide by any accommodations granted by the University Services for Students with Disabilities (SSD) Office. If you have a disability, you can request accommodations to the SSD office at https://ssd.umich.edu/, or by phone: (734) 763-3000. They will issue a verified individual services accommodation (VISA) form. Please email me this form so I can provide the accommodations.

Religious/Cultural Observance: Students who have religious or cultural observances that coincide with this class should let the Instructor know via email within the 3 weeks from the start of the course. Students who expect to miss classes or other assignments as a consequence of their religious observance will be provided with an alternative opportunity to complete their academic responsibilities.

Land Acknowledgment: The University of Michigan resides on the ancestral, traditional, and contemporary lands of the Anishinaabeg: The Three Fire Confederacy of the Ojibwe, Odawa, and Potawatomi Nations, and the Wyandot Nation. Acknowledging the past in itself does not account for the ongoing consequences of colonization. The goal with this statement is to at least develop an understanding of the past, and position ourselves for a future that supports equity, inclusion, and justice for all individuals.

Acknowledgments: This course adapts materials developed by Hamsa Balakrishnan, Peter P. Belobaba, R. John Hansman, Alexandre Jacquillat, Richard de Neufville, Amedeo R. Odoni, Tom G. Reynolds, Megan S. Ryerson, among others. Explicit and appropriate credits are given in lecture slides and materials. I thank Vasileios Tzoumas for sections of this syllabus, which are heavily borrowed from his syllabus for AEROSP 584.

Recommended Readings: Reading material will be listed here for each lecture, corresponding to the lecture number in the Course Calendar above. For each lecture, **foundational and background reading will be marked with [F]**, whereas **research, technical write-ups, and white papers will be marked with [R]**. Please reach out to Max (in class, via email, etc.) if you're interested in more readings about a particular topic. *NB: Unless stated otherwise, the links provided (e.g., URLs, DOI) for the reading materials will provide access to the readings if accessed through UM's network, or through UM's library proxy (see this link). Please contact Max if you have difficulty accessing any materials.*

Lecture 1: Introduction and Course Overview

N/A

Lecture 2: Airline Business

[F] Chapters 1, 3, and 5 in *The Global Airline Industry, 2nd Edition* by Belobaba, Odoni, and Barnhart (2015). UM students can access the book via UM's network/library proxy through this link.

[R] A. R. Bachwich, M. D. Wittman, "The emergence and effects of the ultra-low cost carrier (ULCC) business model in the U.S. airline industry," *Journal of Air Transport Management*, Volume 62, 2017, Pages 155-164, https://doi.org/10.1016/j.jairtraman.2017.03.012.

[R] D. Khezrimotlagh, S. Kaffash, J. Zhu, "U.S. airline mergers' performance and productivity change," *Journal of Air Transport Management*, Volume 102, 2022, https://doi.org/10.1016/j.jairtraman.2022.102226.

[R] M. S. Ryerson, H. Kim, "The impact of airline mergers and hub reorganization on aviation fuel consumption," *Journal of Cleaner Production*, Volume 85, 2014, Pages 395-407, https://doi.org/10.1016/j.jclepro.2013.12.032.

[R] Y. S. Y. Maung, I. Douglas, D. Tan, "Identifying the drivers of profitable airline growth," *Transport Policy*, Volume 115, 2022, Pages 275-285, https://doi.org/10.1016/j.tranpol.2021.11.007.

[R] C. Wang, W. Zhang, Y. Dai, Y. Lee, "Frequency competition among airlines on coordinated airports network," *European Journal of Operational Research*, Volume 297, Issue 2, 2022, Pages 484-495, https://doi.org/10.1016/j.ejor.2021.04.037.

[R] M. D. Wittman, "Are low-cost carrier passengers less likely to complain about service quality?" *Journal of Air Transport Management*, Volume 35, 2014, Pages 64-71, https://doi.org/10.1016/j.jairtraman.2013.11.008.

Lecture 3: Airline Schedule Development Process

[F] Chapters 7 and 6 in *The Global Airline Industry, 2nd Edition* by Belobaba, Odoni, and Barnhart (2015). UM students can access the book via UM's network/library proxy through this link.

[R] C. Barnhart, T. S. Kniker, M. Lohatepanont, "Itinerary-Based Airline Fleet Assignment," *Transportation Science*, 36(2):199-217, 2002, https://doi.org/10.1287/trsc.36.2.199.566.

[R] S. Birolini, A. P. Antunes, M. Cattaneo, P. Malighetti, S. Paleari, "Integrated flight scheduling and fleet assignment with improved supply-demand interactions," *Transportation Research Part B: Methodological*, Volume 149, 2021, Pages 162-180, https://doi.org/10.1016/j.trb.2021.05.001.

[R] J. K. Brueckner, A. I. Czerny, A. A. Gaggero, "Airline mitigation of propagated delays via schedule buffers: Theory and empirics," *Transportation Research Part E: Logistics and Transportation Review*, Volume 150, 2021, https://doi.org/10.1016/j.tre.2021.102333.

[R] C. A. Hane, C. Barnhart, E. L. Johnson, R. E. Marsten, G. L. Nemhauser, G. Sigismondi, "The fleet assignment problem: Solving a large-scale integer program," *Mathematical Programming*, 70, 211–232, 1995, https://doi.org/10.1007/BF01585938.

[R] M. Lohatepanont, C. Barnhart, "Airline Schedule Planning: Integrated Models and Algorithms for Schedule Design and Fleet Assignment," *Transportation Science*, 38(1):19-32, 2004, https://doi.org/10.1287/trsc.1030.0026.

[R] H. D. Sherali, X. Zhu, "Two-Stage Fleet Assignment Model Considering Stochastic Passenger Demands," *Operations Research*, 56(2):383-399, 2008, https://doi.org/10.1287/opre.1070.0476.

[R] X. Wen, X. Sun, Y. Sun, X. Yue, "Airline crew scheduling: Models and algorithms," *Transportation Research Part E: Logistics and Transportation Review*, Volume 149, 2021, https://doi.org/10.1016/j.tre.2021.102304.

Lecture 4: Airline Revenue Management (1/2)

[F] Chapter 4 in *The Global Airline Industry, 2nd Edition* by Belobaba, Odoni, and Barnhart (2015). UM students can access the book via UM's network/library proxy through this link.

[F] P. P. Belobaba, "Survey Paper – Airline Yield Management An Overview of Seat Inventory Control," *Transportation Science*, 21(2):63-73, 1987, https://doi.org/10.1287/trsc.21.2.63.

[F] J. I. McGill, G. J. van Ryzin, "Revenue Management: Research Overview and Prospects," *Transportation Science*, 33(2):233-256, 1999, https://doi.org/10.1287/trsc.33.2.233.

[R] P. P. Belobaba, "Optimization models in RM systems: Optimality versus revenue gains," *Journal of Revenue and Pricing Management*, 15, 229–235, 2016, https://doi.org/10.1057/rpm.2016.13.

[R] Y. Chen, C. Shi, "Network Revenue Management with Online Inverse Batch Gradient Descent Method", https://ssrn.com/abstract=3331939.

[R] G. Escovar-Álvarez, P. P. Belobaba, "Premium cabin capacity sharing strategies: airline RM insights," *Journal of Revenue and Pricing Management,* 21, 3–16, 2022, https://doi.org/10.1057/s41272-021-00326-x.

[R] S. Mumbower, S. Hotle, L. A. Garrow, "Highly debated but still unbundled: The evolution of U.S. airline ancillary products and pricing strategies," *Journal of Revenue and Pricing Management*, 2002, https://doi.org/10.1057/s41272-022-00388-5.

[R] B. Szymański, P. P. Belobaba, A. Papen, "Continuous pricing algorithms for airline RM: revenue gains and competitive impacts," *Journal of Revenue and Pricing Management,* 20, 669–688, 2021, https://doi.org/10.1057/s41272-021-00350-x.

[R] D. Walczak, S. Mardan, R. Kallesen, "Customer choice, fare adjustments and the marginal expected revenue data transformation: A note on using old yield management techniques in the brave new world of pricing," *Journal of Revenue and Pricing Management,* 9, 94–109, 2010, https://doi.org/10.1057/rpm.2009.38.

[R] K. K. Wang, M. D. Wittman, A. Bockelie, "Dynamic offer generation in airline revenue management," *Journal of Revenue and Pricing Management,* 20, 654–668, 2021, https://doi.org/10.1057/s41272-021-00349-4.

[R] M. D. Wittman, P. P. Belobaba, "Dynamic pricing mechanisms for the airline industry: a definitional framework," *Journal of Revenue and Pricing Management*, 18, 100–106, 2019, https://doi.org/10.1057/s41272-018-00162-6.

Lecture 5: Airline Revenue Management (2/2)

See Lecture 4

Lecture 6: **Guest Lecture by Alex Bachwich, United Airlines**

TBD

Lecture 7: Airport Design and Planning (1/2)

[F] Chapters 1, 2, 9, and 15 in *Airport Systems: Planning, Design, and Management, 2nd Edition* by de Neufville, Odoni, Belobaba, and Reynolds (2013). UM students can access the book via UM's network/library proxy through this link.

[R] L. Adacher, M. Flamini, "Optimization of airport check-in service quality focused on operational costs and passengers' satisfaction," *PLOS ONE,* 16(8), 2021, https://doi.org/10.1371/journal.pone.0253586.

[R] S. Atallah, S. Hotle, "Evaluation of Airport Size and Delay Causal Factor Effects on Delay Propagation Dissipation," *Transportation Research Record: Journal of the Transportation Research Board,* 2676(3), 608-620, 2021, https://doi.org/10.1177/03611981211055663.

[R] G. C. L. Bezerra, E. M. de Souza, A. R. Correia, "Passenger expectations and airport service quality: Exploring customer segmentation," *Transportation Research Record,* 2675(10), 604-615, 2021, https://doi.org/10.1177/03611981211011992.

[R] T. Grippa, F. Dobruszkes, "You're Surrounded! Measuring the Enclosure of Airports in Urban Areas," *The Professional Geographer,* 1-16, 2022, https://doi.org/10.1080/00330124.2022.2081226.

[R] T. H. Kim, C. L. Wu, "Methodology for defining the new optimum level of service in airport passenger terminals," *Transportation Planning and Technology,* 44(4), 378-399, 2021, https://doi.org/10.1080/03081060.2021.1919348.

[R] M. Takebayashi, "Workability of a multiple-gateway airport system with a high-speed rail network," *Transport Policy,* 107, 61-71, 2021, https://doi.org/10.1016/j.tranpol.2021.04.019.

[R] R. Tani, I. Takashima, T. Kato, T. Tamura, K. Uchida, "Analysis of the effect of bundled airport privatization on an airline network," *Transport Policy,* 2021, https://doi.org/10.1016/j.tranpol.2021.04.021.

[R] M. Waltert, J. Wicki, E. Jimenez Perez, R. Pagliari, "Ratio-based design hour determination for airport passenger terminal facilities," *Journal of Air Transport Management,* 96, 2021, https://doi.org/10.1016/j.jairtraman.2021.102125.

[R] S. Yin, K. Han, W. Y. Ochieng, D. R. Sanchez, "Joint apron-runway assignment for airport surface operations," *Transportation Research Part B: Methodological,* 156, 76-100, 2022, https://doi.org/10.1016/j.trb.2021.12.011.

[R] National Research Council, "Airport Parking Pricing Strategies," *Washington, DC: The National Academies Press,* 2022, https://doi.org/10.17226/26671.

Lecture 8: Airport Design and Planning (2/2)

See Lecture 7

Lecture 9: Airport Capacity (1/2)

[F] Chapters 5, 10, and 11 in *Airport Systems: Planning, Design, and Management, 2nd Edition* by de Neufville, Odoni, Belobaba, and Reynolds (2013). UM students can access the book via UM's network/library proxy through this link.

[R] S. Choi, Y. J. Kim, "Artificial neural network models for airport capacity prediction," *Journal of Air Transport Management,* 97, 2021, https://doi.org/10.1016/j.jairtraman.2021.102146.

[R] X. Guo, Y. Grushka-Cockayne, B. de Reyck, "Forecasting Airport Transfer Passenger Flow Using Real-Time Data and Machine Learning," *Manufacturing & Service Operations Management,* 2021, https://doi.org/10.1287/msom.2021.0975.

[R] G. Gurtner, A. Cook, A. Graham, S. Cristóbal, "The economic value of additional airport departure capacity," *Journal of Air Transport Management,* 69, 1-14, 2018, https://doi.org/10.1016/j.jairtraman.2018.01.001.

[R] S. Khater, J. Rebollo, W. J. Coupe, "A Recursive Multi-step Machine Learning Approach for Airport Configuration Prediction," *AIAA Aviation and Aeronautics Forum and Exposition, AIAA AVIATION Forum 2021,* 2021, https://doi.org/10.2514/6.2021-2406.

[R] D. J. Lovell, K. Vlachou, T. Rabbani, A. Bayen, "A diffusion approximation to a single airport queue," *Transportation Research Part C: Emerging Technologies,* 33, 227-237, 2013, https://doi.org/10.1016/j.trc.2012.04.010.

[R] D. Lubig, M. Schultz, H. Fricke, F. Herrema, R. B. Montes, B. Desart, "Propagation of Airport Capacity Improvements to the Air Transport Network," *AIAA/IEEE Digital Avionics Systems Conference - Proceedings,* 2021, https://doi.org/10.1109/DASC52595.2021.9594352.

[R] G. N. Lui, K. K. Hon, R. P. Liem, "Weather impact quantification on airport arrival on-time performance through a Bayesian statistics modeling approach," *Transportation Research Part C: Emerging Technologies,* 143, 103811, https://doi.org/10.1016/j.trc.2022.103811.

[R] N. Pyrgiotis, K. M. Malone, A. Odoni, "Modelling delay propagation within an airport network," *Transportation Research Part C: Emerging Technologies,* 27, 60-75, 2013, https://doi.org/10.1016/j.trc.2011.05.017.

[R] M. Schultz, R. Reitmann, S. Alam, "Predictive classification and understanding of weather impact on airport performance through machine learning," *Transportation Research Part C: Emerging Technologies,* 131, 2021, https://doi.org/10.1016/j.trc.2021.103119.

Lecture 10: Airport Capacity (2/2)

See Lecture 9

Lecture 11: Airport Demand Management (1/2)

[F] Chapters 12, 13, 20, and 21 in *Airport Systems: Planning, Design, and Management, 2nd Edition* by de Neufville, Odoni, Belobaba, and Reynolds (2013). UM students can access the book via UM's network/library proxy through this link.

[R] M. Bichler, P. Gritzmann, P. Karaenke, M. Ritter, "On Airport Time Slot Auctions: A Market Design Complying with the IATA Scheduling Guidelines," *Transportation Science,* 2022, https://doi.org/10.1287/trsc.2022.1166.

[R] S. Birolini, A. Jacquillat, P. Schmedeman, N. Ribeiro, "Passenger-Centric Slot Allocation at Schedule-Coordinated Airports," *Transportation Science,* 2022, https://doi.org/10.1287/trsc.2022.1165.

[R] M. Hou, K. Wang, H. Yang, "Hub airport slot Re-allocation and subsidy policy to speed up air traffic recovery amid COVID-19 pandemic – case on the Chinese airline market," *Journal of Air Transport Management,* 93, 2021, https://doi.org/10.1016/j.jairtraman.2021.102047.

[R] A. Jacquillat, A. R. Odoni, "An Integrated Scheduling and Operations Approach to Airport Congestion Mitigation," *Operations Research,* 63(6), 1390-1410, 2016, https://doi.org/10.1287/opre.2015.1428.

[R] A. Jacquillat, V. Vaze, "Interairline Equity in Airport Scheduling Interventions," *Transportation Science,* 52(4), 941-964, 2018, https://doi.org/10.1287/trsc.2017.0817.

[R] Y. Jiang, K. G. Zografos, "A decision making framework for incorporating fairness in allocating slots at capacity-constrained airports," *Transportation Research Part C: Emerging Technologies,* 126, 2021, https://doi.org/10.1016/j.trc.2021.103039.

[R] S. H. Kim, "Pretactical Runway Operations Scheduling for Multirunway Airport," *Journal of Aerospace Information Systems,* 1-10, 2022, https://doi.org/10.2514/1.I011062.

[R] W. Liu, Q. Zhao, D. Delahaye, "Research on slot allocation for airport network in the presence of uncertainty," *Journal of Air Transport Management,*, 104, 102269, 2022, https://doi.org/10.1016/j.jairtraman.2022.102269.

[R] P. Pellegrini, L. Castelli, R. Pesenti, "Secondary trading of airport slots as a combinatorial exchange," *Transportation Research Part E: Logistics and Transportation Review,* 48(5), 1009-1022, 2012, https://doi.org/10.1016/j.tre.2012.03.004.

[R] N. A. Ribeiro, A. Jacquillat, A. P. Antunes, A. R. Odoni, J. P. Pita, "An optimization approach for airport slot allocation under IATA guidelines," *Transportation Research Part B: Methodological,* 112, 132-156, 2018, https://doi.org/10.1016/j.trb.2018.04.005.

[R] M. S. Ryerson, A. W. McNair, "Build airport capacity or manage flight demand? How regional planners can lead American aviation into a new frontier of demand management," *Journal of the American Planning Association,* 80(20), 138-152, 2014, https://doi.org/10.1080/01944363.2014.961949.

Lecture 12: Airport Demand Management (2/2)

See Lecture 11

Lecture 13: Airport Environmental Considerations

[F] Chapter 6 in *Airport Systems: Planning, Design, and Management, 2nd Edition* by de Neufville, Odoni, Belobaba, and Reynolds (2013). UM students can access the book via UM's network/library proxy through this link.

[R] F. Doctor, T. Budd, P. D. Williams, M. Prescott, R. Iqbal, "Modelling the effect of electric aircraft on airport operations and infrastructure," *Technological Forecasting and Social Change,* 177, 2022, https://doi.org/10.1016/j.techfore.2022.121553.

[R] M. Kamruzzaman, L. Aston, D. Baker, B. Braun, F. Shatu, "Changes in land use typology of global airports: An empirical investigation with implications for the aerotropolis concept," *Journal of Transport Geography,* 97, 2021, https://doi.org/10.1016/j.jtrangeo.2021.103217.

[R] Y. Kidokoro, A. Zhang, "Airport cities and social welfare," *Transportation Research Part B: Methodological,* 158, 187-209, 2022, https://doi.org/10.1016/j.trb.2021.12.010.

[R] C. K. Marete, M. E. Johnson, "Case study of social sustainability practices in U.S. small hub airports," *Transportation Research Record,* 2675(10), 916-926, 2021, https://doi.org/10.1177/03611981211014209.

[R] M. C. P. Poo, Z. Yang, D. Dimitriu, Z. Qu, "An advanced climate resilience indicator framework for airports: A UK case study," *Transportation Research Part D: Transport and Environment,* 101, 2021, https://doi.org/10.1016/j.trd.2021.103099.

[R] M. Pretto, P. Giannattasio, M. de Gennaro, "Mixed analysis-synthesis approach for estimating airport noise from civil air traffic," *Transportation Research Part D: Transport and Environment,* 106, 103248, 2022, https://doi.org/10.1016/j.trd.2022.103248.

[R] M. C. Simon, J. E. Hart, J. I. Levy, T. Vopham, A. Malwitz, D. Nguyen, M. Bozigar, L. A. Cupples, P. James, F. Laden, J. L. Peters, "Sociodemographic Patterns of Exposure to Civil Aircraft Noise in the United States," *Environmental Health Perspectives,* 130(2), 2022, https://doi.org/10.1289/EHP9307.

[R] A. W. McNair, "Investigating Neighborhood Change in Airport-Adjacent Communities in Multiairport Regions, 1970–2010," *Transportation Research Record: Journal of the Transportation Research Board,* 2626(1), 2017, https://doi.org/10.3141/2626-01.

[R] A. W. McNair, "Investigation of environmental justice analysis in airport planning practice from 2000 to 2010," *Transportation Research Part D: Transport and Environment,* 101, 2021, https://doi.org/10.1016/j.trd.2020.102286.

[R] K. W. Yirgu, A. M. Kim, "Aviation fuel and emissions in air markets with interregional passenger leakage," *Transportation Research Part D: Transport and Environment,* 101, 2021, https://doi.org/10.1016/j.trd.2021.103092.

Lecture 14: Airline Dispatch, Day-of Ops

[F] M. D. D. Clarke, "Irregular airline operations: a review of the state-of-the-practice in airline operations control centers," *Journal of Air Transport Management,* 4(2), 67-76, 1998, https://doi.org/10.1016/S0969-6997(98)00012-X.

[R] *See lecture slides for cited references.*

Lecture 15: NAS Overview (En Route)

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[F], [R] *See lecture slides for cited references.*

Lecture 16: NAS Overview (Terminal Operations)

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[F], [R] *See lecture slides for cited references.*

Lecture 17: ATC/ATM: Ground Holding Problem

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[F], [R] *See lecture slides for cited references.*

Lecture 18: ATC/ATM: Air Traffic Flow Management Problem

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[F], [R] *See lecture slides for cited references.*

Lecture 19: Air Traffic Network Models

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[F], [R] *See lecture slides for cited references.*

Lecture 20: Air Cargo & Other Users

-

[F], [R] *See lecture slides for cited references.*

Lecture 21: **Guest Lecture by Dr. Stéphane Mondoloni, The MITRE Corporation**

Lecture 22: UAS and AAM

-

[F], [R] *See lecture slides for cited references.*

Lecture 23: Commercial Space Ops

-

[F], [R] *See lecture slides for cited references.*

University of Michigan
Fall 2022 Instructor Report
AEROSP 740-001: Sp Top Fltdyn Con
Max Li

14 out of 18 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)	11	3	0	0	0	0	4.9	4.5	4.7
My interest in the subject has increased because of this course. (Q1632)	10	4	0	0	0	0	4.8	4.2	4.5
I knew what was expected of me in this course.(Q1633)	7	7	0	0	0	0	4.5	4.6	4.6
I had a strong desire to take this course.(Q4)	10	4	0	0	0	0	4.8	4.0	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)	0	4	6	4	0	0	3.0	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
Max Li seemed well prepared for class meetings. (Q230)	11	3	0	0	0	0	4.9	4.8	4.8
Max Li explained material clearly.(Q199)	11	3	0	0	0	0	4.9	4.7	4.7
Max Li treated students with respect.(Q217)	13	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)	11	2	0	0	0	0	4.9
I increased my ability to apply math and science knowledge to engineering problems. (Q15)	8	4	1	1	0	0	4.6
I increased my ability to formulate, and solve engineering problems. (Q23)	5	6	2	1	0	0	4.2
I increased my ability to apply engineering tools and methods. (Q35)	5	7	1	0	0	1	4.3

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Max Li was an excellent teacher. (Q2)	11	3	0	0	0	0	4.9

The medians are calculated from Fall 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
Fall 2023 Instructor Report
AEROSP 740-001: Sp Top Fltdyn Con
Max Li

22 out of 27 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)	15	7	0	0	0	0	4.8	4.5	4.5
My interest in the subject has increased because of this course. (Q1632)	12	7	1	2	0	0	4.6	4.2	4.2
I knew what was expected of me in this course.(Q1633)	7	10	4	1	0	0	4.1	4.4	4.5
I had a strong desire to take this course.(Q4)	16	5	1	0	0	0	4.8	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)	0	5	15	2	0	0	3.1	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
Max Li seemed well prepared for class meetings. (Q230)	17	5	0	0	0	0	4.9	4.7	4.8
Max Li explained material clearly.(Q199)	14	6	2	0	0	0	4.7	4.6	4.7
Max Li treated students with respect.(Q217)	19	2	1	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)	14	8	0	0	0	0	4.7
I increased my ability to apply math and science knowledge to engineering problems. (Q15)	11	7	4	0	0	0	4.5
I increased my ability to formulate, and solve engineering problems. (Q23)	8	12	2	0	0	0	4.3
I increased my ability to apply engineering tools and methods. (Q35)	9	9	4	0	0	0	4.3

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Max Li was an excellent teacher. (Q2)	18	4	0	0	0	0	4.9

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 16 to 74 in College of Engineering.

Course Approval Request Form

Office of the Registrar, University of Michigan

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

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

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

Date of Submission: 2024-09-16
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): Electrical & Computer Engineering Subject: ECE Catalog: 602	Dept (Home): Electrical & Computer Engineering Subject: ECE Catalog: 567
☐	☐ 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) Reinforcement Learning Theory	Course Title (full title) Reinforcement Learning Theory
☐	Abbreviated Title (20 char) ReinforceLearnTheory	Abbreviated Title (20 char) ReinforceLearnTheory
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Basic theories and principles of reinforcement learning, and model-based and model-free reinforcement learning algorithms. Topics: Value iteration, policy iteration, Q-learning, SARSA, policy-gradient, variance reduction, linear and nonlinear function approximation, deep reinforcement learning, exploration-exploitation, convergence analysis, regret analysis.	
☐	Full Term Credit Hours Undergraduate Min: Graduate Min: 3 Undergraduate Max: Graduate Max: 3	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: 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: Electrical & Computer Engineering Catalog: 602

☐	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) ECE 501	Advisory Prerequisite (254 char) ECE 501
☐	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: Lei Ying 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:		Print: Achilleas Anastasopoulos	Date: 9/23/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Peter Seiler	Date: 9/20/2024
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 Basic theories and principles of reinforcement learning, and model-based and model-free reinforcement learning algorithms. Topics: Value iteration, policy iteration, Q-learning, SARSA, policy-gradient, variance reduction, linear and nonlinear function approximation, deep reinforcement learning, exploration-exploitation, convergence analysis, regret analysis.	Course Description Basic theories and principles of reinforcement learning, and model-based and model-free reinforcement learning algorithms. Topics: Value iteration, policy iteration, Q-learning, SARSA, policy-gradient, variance reduction, linear and nonlinear function approximation, deep reinforcement learning, exploration-exploitation, convergence analysis, regret analysis.
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:

Special resources of facilities required for this course:

Supporting statement:
ECE 602 (formerly EECS 602) is an entry-level graduate course on reinforcement learning. ECE 602 was chosen due to the lack of available course numbers at the 500-level at the time. The request is to change 602 to ECE 567 to better reflect the difficulty level of 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: 2024-09-16
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): Electrical & Computer Engineering Subject: ECE Catalog: 995	Dept (Home): Electrical & Computer Engineering Subject: ECE Catalog: 995
☐	☐ 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) Dissertation/Candidate	Course Title (full title) Dissertation/Candidate
☐	Abbreviated Title (20 char) Diss-Cand	Abbreviated Title (20 char) Diss-Cand
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Election for dissertation work by a doctoral student who has been admitted to candidate status. The defense of the dissertation, that is, the final oral examination, must be held under a full-term candidacy enrollment.	
☐	Full Term Credit Hours Undergraduate Min: Graduate Min: 4 Undergraduate Max: Graduate Max: 8	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type 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: 995

☐	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) Candidate 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: Peter Seiler 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:		Print: Achilleas Anastasopoulos	Date: 9/20/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Peter Seiler	Date: 9/20/24
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 Election for dissertation work by a doctoral student who has been admitted to candidate status. The defense of the dissertation, that is, the final oral examination, must be held under a full-term candidacy enrollment.	Course Description Election for dissertation work by a doctoral student who has been admitted to candidate status. The defense of the dissertation, that is, the final oral examination, must be held under a full-term candidacy enrollment.
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 5 currently does not include the requirement of candidacy. Adding this enforced prerequisite to comply with the Rackham rule.

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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: 2024-05-16
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): Industrial & Operations Engin Subject: IOE Catalog: 567
☐	☐ 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)	Course Title (full title) Modern Bayesian Data Science
☑	Abbreviated Title (20 char)	Abbreviated Title (20 char) Bayesian Data Sci
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Bayesian Fundamentals, Single & Multivariate Parameter Models, Bayesian Model Evaluation, Bayesian Decision Analysis, Modern Markov Chain Monte Carlo, Bayesian Regression, Variational Inference: Posterior Inference via Optimization, Gaussian Processes, Bayesian Deep Learning, Bayesian Optimization, and Distributed Bayesian Analysis. Significant focus is also placed on applications of Bayesian data science and modeling of real-life data using coding software.	
☑	Full Term Credit Hours Undergraduate Min: Graduate Min: 3 Undergraduate Max: Graduate Max: 3	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☑	Course Credit Type 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

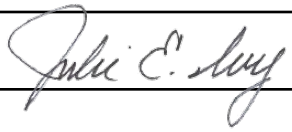
	CURRENT LISTING	**REQUESTED LISTING**
☑	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char) Knowledge of basic statistics at the level of IOE 265 or STATS 250. Knowledge in linear algebra at the level of MATH 417 Proficiency in data visualization using R, Python, or MATLAB
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☑	Credit Exclusions	Credit Exclusions Credit is granted for only 1 course from IOE 567, IOE 667.

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

Cognizant Faculty Member Name: Raed Al Kontar	Cognizant Faculty Member Title: Assistant Professor

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

Contact Person: Leonora Lucaj Email: lucajl@umich.edu Phone: 734-764-3297

CoE Curriculum Committee Representative: Yavuz Bozer		Print: Yavuz Bozer	Date: 09/19/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair: Julie Ivy		Print: Julie Simmons Ivy	Date: 09/19/24
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	Course Description Bayesian Fundamentals, Single & Multivariate Parameter Models, Bayesian Model Evaluation, Bayesian Decision Analysis, Modern Markov Chain Monte Carlo, Bayesian Regression, Variational Inference: Posterior Inference via Optimization, Gaussian Processes, Bayesian Deep Learning, Bayesian Optimization, and Distributed Bayesian Analysis. Significant focus is also placed on applications of Bayesian data science and modeling of real-life data using coding software.
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:
In today's data-driven world, Bayesian methods stand as a robust solution for navigating uncertainty and facilitating informed decision-making across diverse domains, encompassing finance, healthcare, marketing, and machine learning. They have proven indispensable in modern data analysis.

This course ensures Master's students are well-prepared to apply Bayesian techniques effectively to real-world challenges. Through the integration of foundational principles with contemporary applications, students will develop a thorough understanding of the practical advantages, limitations, and implications of Bayesian theory. Additionally, the emphasis on implementing the methodology via coding will enable students to contextualize the methods taught and understand how to apply them across various applications.

The course aligns with IOE's data analytics research thrust and augments existing data analytics courses such as IOE/STAT 570 (Experimental Design) and IOE 366 (Introduction to Engineering Data Analytics) by introducing Bayesian learning elements and addressing contemporary data challenges where Bayesian theory plays a pivotal role in shaping informed decision-making.

Difference between IOE 567 and IOE 667

First, it is important to note that since its inception, the course syllabus has stated that IOE 691 is intended for both master's and Ph.D. students. Indeed, approximately 50% of the students enrolled in IOE 691 each semester have been master's students.

My plan to distinguish IOE 567 and IOE 667 primarily involves having IOE 667 spend some effort practicing and studying derivations and proofs related to Bayesian theory, while IOE 567 will emphasize coding and simulations.

Moving forward, I plan to have five assignments throughout the semester. Each assignment will be split into three sections:

Homework

- Core Assignment – Required for both IOE 567 and IOE 667
- Coding Part – Required for IOE 567, but optional for IOE 667
- Additional Derivation Questions – Required for IOE 667, but optional for IOE 567

Midterm

The midterms for the two courses will be different. For IOE 567, the focus will be on coding, whereas for IOE 667, some coding questions will be replaced with derivation questions.

Projects

Our class project involves studying an impactful paper in Bayesian data science on a topic that extends what was taught in class, replicating the simulation results in the paper, running a new simulation on a large-scale dataset not used in the paper, and then providing a presentation and code for all the results. These projects count for a significant portion of the grade. To distinguish the two classes:

- IOE 567 will study applied papers that do not delve into proofs but rather apply Bayesian inference in new application fields.
- IOE 667 will study theoretical Bayesian papers and will need to understand the proofs and derivations.

Note on Homework:

In past semesters, I evaluated students primarily based on a long take-home assignment and a comprehensive project. This semester, I planned two homework assignments but asked the students if they preferred two assignments or a longer, more comprehensive midterm. The majority chose the longer midterm. However, I acknowledge that some students prefer learning through weekly homework, which is especially important for master's students if we split the class into IOE 567 and 667. This preference was reflected in some feedback I received on the evaluations.
Therefore, I am committed to assigning five homework tasks the next time I teach this class. I will also provide the homework assignments to the IOE curriculum committee before the class begins.

IOE 691 – Modern Bayesian Data Science
COURSE SYLLABUS – Winter 23

Lecture: Wednesday 4:30 – 7:30 pm (1680 IOE)

Instructor Team

Instructor: Raed Al Kontar (alkontar@umich.edu)
Office Hours:

- Time: 1:30 – 2:30 on Monday
- Location: IOE 2715
- Zoom: https://umich.zoom.us/j/ 9533054474, passcode: 123

How to Contact Us

- Email: Use ioe691w24@umich.edu to communicate with the instructor
- You may reach the instructor by email at any time to arrange a meeting if you cannot attend office hours.

All lectures will be recorded and uploaded directly after the class.

Reference Textbooks

- Bayesian Data Analysis – Third edition
- Pattern Recognition and Machine Learning

Both books have an electronic version available for non-commercial purposes. They have also been made available via the UM Library.

Audience

The course is intended for both master's and Ph.D. students.

Prerequisites

1) Knowledge of basic probability concepts
2) Basic knowledge in algebra and calculus, mainly linear algebra and calculus I and II
3) Knowledge of data visualization using R, Python, or MATLAB

Overview

IOE 691 covers the fundamentals of Bayesian data science and tackles contemporary topics where Bayesian analysis plays a central role. The class will place a significant focus on applications of Bayesian data science.

Topics covered in this class are:

1. Bayesian Fundamentals
2. Single & Multivariate Parameter Models
3. Bayesian Model Evaluation
4. Bayesian Decision Analysis
5. Modern MCMC: Optimization Meets Sampling
6. Bayesian Regression
7. Variational Inference: Posterior Inference Via Optimization
8. Modern Gaussian Processes
9. Bayesian Deep Learning
10. Bayesian Optimization and Sequential Optimal Design
11. Decentralized & Distributed Bayesian Analysis

A course pack has been uploaded to Canvas that include slides, code (written in R) and results for each topic covered.

Course Grades

Homework (2)	15%
Midterm	30%
Final Project	50%
Participation	5%
Total Score	100%

If you attend 4 or more classes throughout the semester and the last two lectures for student presentations, you will get the 5% participation grade. Partial participation out of 5% will be provided if you do not meet the requirements above.

Late Submission

- We do not accept late submissions of homework unless well-justified as determined by the instructor

Honor Code

All students are expected to be familiar with the Engineering Honor Code and are bound by its requirements.

Mental Health

Please be aware of the following resources. 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/ 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/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/~mealth/.

DEI Statement:

At U-M Industrial and Operations Engineering (IOE), we value all people and are committed to promoting diversity, equity and inclusion (DEI) in its fullest form for everyone in our community and beyond. We advance scientific and mathematical methods and develop engineering technologies to help solve human-centered local and global challenges; meaning we impact people, processes, and systems through generating and analyzing data across a range of applications. Not only does incorporating DEI principles make our solutions more powerful, applicable, and ethical, promoting and fostering DEI is a core value of the IOE community and leadership. At U-M IOE we view DEI as interwoven with our research, teaching, and community involvement.
At U-M Industrial and Operations Engineering, we value diversity, equity and inclusion (DEI) for all people in our community.

The Department of Industrial and Operations Engineering is dedicated to providing an environment that is inclusive, supportive, and respectful. If we fall short, we want to hear from you. Use our website to learn about ways to report concerns or misconduct anonymously, confidentially, or formally, and know that you will be heard, you will be taken seriously, and the U-M IOE community will stand behind you.
https://sites.google.com/umich.edu/report-concerns-and-misconduct/

Class Schedule

Date	Topic
Week 0	
10-Jan	Lecture 1: Fundementals & Single Parameter Models
Week 1	
17-Jan	Lecture 1: Fundementals & Single Parameter Models
Week 2	
24-Jan	Lecture 2: Single & Multiple Parameter Models
Week 3	
31-Jan	Lecture 3: Multiple Parameter Models & Numerics
Week 4	
7-Feb	Lecture 4: Numerics & MCMC
Week 5	
14-Feb	Lecture 5: MCMC & HMC
Week 6	
21-Feb	Midterm
Week 7	
28-Feb	Fall Break
Week 8	
6-Mar	Lecture 6: Heirarichal Models and Finished HMC
Week 9	
13-Mar	Lecture 7: Model Checking
Week 10	
20-Mar	Lecture 8: Gaussian process, Decision Analysis and BO
Week 11	
27-Mar	Lecture 9: Normal Approximations & Variational Inference
Week 12	
3-Apr	Lecture 10: Bayesian deep learning
Week 13	
10-Apr	Projects
Week 14	
17-Apr	Projects

University of Michigan
Winter 2022 Instructor Report With Comments
IOE 691-077: Special Topics
Raed Al Kontar

13 out of 28 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)	8	5	0	0	0	0	4.7	4.6	4.7
My interest in the subject has increased because of this course. (Q1632)	7	4	1	1	0	0	4.6	4.2	4.6
I knew what was expected of me in this course.(Q1633)	6	1	5	1	0	0	4.0	4.6	4.5
I had a strong desire to take this course.(Q4)	8	3	1	1	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	5	2	1	0	1	4.1	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
Raed Al Kontar seemed well prepared for class meetings.(Q230)	10	2	0	1	0	0	4.9	4.8	4.8
Raed Al Kontar explained material clearly.(Q199)	6	3	2	2	0	0	4.3	4.7	4.7
Raed Al Kontar treated students with respect.(Q217)	8	4	0	0	0	0	4.8	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)	6	3	2	2	0	0	4.3
Examinations covered the important aspects of the course. (Q356)	5	1	1	1	0	5	4.7

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Raed Al Kontar was an excellent teacher. (Q2)	7	3	2	1	0	0	4.6
Raed Al Kontar stressed important points in lectures/discussions. (Q203)	9	4	0	0	0	0	4.8
Raed Al Kontar appeared to have a thorough knowledge of the subject. (Q207)	11	2	0	0	0	0	4.9
Raed Al Kontar acknowledged all questions insofar as possible. (Q216)	10	2	0	1	0	0	4.9
Raed Al Kontar encouraged constructive criticism. (Q218)	8	4	1	0	0	0	4.7

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
IOE 691-077: Special Topics
Raed Al Kontar

16 out of 18 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)	12	4	0	0	0	0	4.8	4.4	4.5
My interest in the subject has increased because of this course. (Q1632)	11	5	0	0	0	0	4.8	4.1	4.2
I knew what was expected of me in this course.(Q1633)	7	4	4	1	0	0	4.3	4.3	4.6
I had a strong desire to take this course.(Q4)	11	4	1	0	0	0	4.8	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	7	6	0	0	0	3.8	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
Raed Al Kontar seemed well prepared for class meetings.(Q230)	13	3	0	0	0	0	4.9	4.7	4.8
Raed Al Kontar explained material clearly.(Q199)	10	5	1	0	0	0	4.7	4.6	4.7
Raed Al Kontar treated students with respect.(Q217)	12	4	0	0	0	0	4.8	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)	10	4	2	0	0	0	4.7
Examinations covered the important aspects of the course. (Q356)	8	4	2	1	0	1	4.6

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Raed Al Kontar was an excellent teacher. (Q2)	11	4	1	0	0	0	4.8
Raed Al Kontar stressed important points in lectures/discussions. (Q203)	13	3	0	0	0	0	4.9
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10 out of 14 students responded to this evaluation.

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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: 2024-04-06
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): Industrial & Operations Engin Subject: IOE Catalog: 667
☐	☐ 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)	Course Title (full title) Modern Bayesian Data Science
☑	Abbreviated Title (20 char)	Abbreviated Title (20 char) Bayesian Data Sci
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Bayesian Fundamentals, Single & Multivariate Parameter Models, Bayesian Model Evaluation, Bayesian Decision Analysis, Modern Markov Chain Monte Carlo, Bayesian Regression, Variational Inference: Posterior Inference via Optimization, Gaussian Processes, Bayesian Deep Learning, Bayesian Optimization, and Distributed Bayesian Analysis. Significant focus is also placed on the theory and applications of Bayesian data science.	
☑	Full Term Credit Hours Undergraduate Min: Graduate Min: 3 Undergraduate Max: Graduate Max: 3	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☑	Course Credit Type 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) Knowledge of basic statistics at the level of IOE 265 or STATS 250. Knowledge in linear algebra at the level of MATH 417 Proficiency in data visualization using R, Python, or MATLAB
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☑	Credit Exclusions	Credit Exclusions Credit is granted for only 1 course from IOE 567, IOE 667.
☑	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☐ Discussion ☐ Independent Study Graded Component ☑ ☐ ☐ ☐ ☐ ☐ Terms Typically Offered ☐ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer	
Cognizant Faculty Member Name: Raed Kontar		Cognizant Faculty Member Title: Assistant Professor

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

Contact Person: Leonora Lucaj Email: lucajl@umich.edu Phone: 734-764-3297

CoE Curriculum Committee Representative: Yavuz Bozer	Yavuz Bozer	Print: Yavuz Bozer	Date: 09/19/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair: Julie Ivy	Julie C. Ivy	Print: Julie Simmons Ivy	Date: 09/19/24
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	Course Description Bayesian Fundamentals, Single & Multivariate Parameter Models, Bayesian Model Evaluation, Bayesian Decision Analysis, Modern Markov Chain Monte Carlo, Bayesian Regression, Variational Inference: Posterior Inference via Optimization, Gaussian Processes, Bayesian Deep Learning, Bayesian Optimization, and Distributed Bayesian Analysis. Significant focus is also placed on the theory and applications of Bayesian data science.
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:
In today's data-driven world, Bayesian methods stand as a robust solution for navigating uncertainty and facilitating informed decision-making across diverse domains, encompassing finance, healthcare, marketing, and machine learning. They have proven indispensable in modern data analysis.

This course ensures students' preparedness to apply Bayesian techniques effectively to real-world challenges. The topics taught encompass both foundational Bayesian analysis concepts and cutting-edge topics.

The course aligns with IOE's data analytics research thrust and augments existing data analytics courses such as IOE/STAT 570 (Experimental Design), IOE 366 (Introduction to Engineering Data Analytics) by introducing Bayesian

learning elements and addressing contemporary data challenges where Bayesian theory plays a pivotal role in shaping informed decision-making.

Difference between IOE 567 and IOE 667

First, it is important to note that since its inception, the course syllabus has stated that IOE 691 is intended for both master's and Ph.D. students. Indeed, approximately 50% of the students enrolled in IOE 691 each semester have been master's students.

My plan to distinguish IOE 567 and IOE 667 primarily involves having IOE 667 spend some effort practicing and studying derivations and proofs related to Bayesian theory, while IOE 567 will emphasize coding and simulations.

Moving forward, I plan to have five assignments throughout the semester. Each assignment will be split into three sections:

Homework

- Core Assignment – Required for both IOE 567 and IOE 667
- Coding Part – Required for IOE 567, but optional for IOE 667
- Additional Derivation Questions – Required for IOE 667, but optional for IOE 567

Midterm

The midterms for the two courses will be different. For IOE 567, the focus will be on coding, whereas for IOE 667, some coding questions will be replaced with derivation questions.

Projects

Our class project involves studying an impactful paper in Bayesian data science on a topic that extends what was taught in class, replicating the simulation results in the paper, running a new simulation on a large-scale dataset not used in the paper, and then providing a presentation and code for all the results. These projects count for a significant portion of the grade. To distinguish the two classes:

- IOE 567 will study applied papers that do not delve into proofs but rather apply Bayesian inference in new application fields.
- IOE 667 will study theoretical Bayesian papers and will need to understand the proofs and derivations.

Note on Homework:

In past semesters, I evaluated students primarily based on a long take-home assignment and a comprehensive project. This semester, I planned two homework assignments but asked the students if they preferred two assignments or a longer, more comprehensive midterm. The majority chose the longer midterm. However, I acknowledge that some students prefer learning through weekly homework, which is especially important for master's students if we split the class into IOE 567 and 667. This preference was reflected in some feedback I received on the evaluations.
Therefore, I am committed to assigning five homework tasks the next time I teach this class. I will also provide the homework assignments to the IOE curriculum committee before the class begins.

IOE 691 – Modern Bayesian Data Science
COURSE SYLLABUS – Winter 23

Lecture: Wednesday 4:30 – 7:30 pm (1680 IOE)

Instructor Team

Instructor: Raed Al Kontar (alkontar@umich.edu)
Office Hours:

- Time: 1:30 – 2:30 on Monday
- Location: IOE 2715
- Zoom: https://umich.zoom.us/j/ 9533054474, passcode: 123

How to Contact Us

- Email: Use ioe691w24@umich.edu to communicate with the instructor
- You may reach the instructor by email at any time to arrange a meeting if you cannot attend office hours.

All lectures will be recorded and uploaded directly after the class.

Reference Textbooks

- Bayesian Data Analysis – Third edition
- Pattern Recognition and Machine Learning

Both books have an electronic version available for non-commercial purposes. They have also been made available via the UM Library.

Audience

The course is intended for both master's and Ph.D. students.

Prerequisites

1) Knowledge of basic probability concepts
2) Basic knowledge in algebra and calculus, mainly linear algebra and calculus I and II
3) Knowledge of data visualization using R, Python, or MATLAB

Overview

IOE 691 covers the fundamentals of Bayesian data science and tackles contemporary topics where Bayesian analysis plays a central role. The class will place a significant focus on applications of Bayesian data science.

Topics covered in this class are:

1. Bayesian Fundamentals
2. Single & Multivariate Parameter Models
3. Bayesian Model Evaluation
4. Bayesian Decision Analysis
5. Modern MCMC: Optimization Meets Sampling
6. Bayesian Regression
7. Variational Inference: Posterior Inference Via Optimization
8. Modern Gaussian Processes
9. Bayesian Deep Learning
10. Bayesian Optimization and Sequential Optimal Design
11. Decentralized & Distributed Bayesian Analysis

A course pack has been uploaded to Canvas that include slides, code (written in R) and results for each topic covered.

Course Grades

Homework (2)	15%
Midterm	30%
Final Project	50%
Participation	5%
Total Score	100%

If you attend 4 or more classes throughout the semester and the last two lectures for student presentations, you will get the 5% participation grade. Partial participation out of 5% will be provided if you do not meet the requirements above.

Late Submission

- We do not accept late submissions of homework unless well-justified as determined by the instructor

Honor Code

All students are expected to be familiar with the Engineering Honor Code and are bound by its requirements.

Mental Health

Please be aware of the following resources. 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/ 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/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/~mealth/.

DEI Statement:

At U-M Industrial and Operations Engineering (IOE), we value all people and are committed to promoting diversity, equity and inclusion (DEI) in its fullest form for everyone in our community and beyond. We advance scientific and mathematical methods and develop engineering technologies to help solve human-centered local and global challenges; meaning we impact people, processes, and systems through generating and analyzing data across a range of applications. Not only does incorporating DEI principles make our solutions more powerful, applicable, and ethical, promoting and fostering DEI is a core value of the IOE community and leadership. At U-M IOE we view DEI as interwoven with our research, teaching, and community involvement.
At U-M Industrial and Operations Engineering, we value diversity, equity and inclusion (DEI) for all people in our community.

The Department of Industrial and Operations Engineering is dedicated to providing an environment that is inclusive, supportive, and respectful. If we fall short, we want to hear from you. Use our website to learn about ways to report concerns or misconduct anonymously, confidentially, or formally, and know that you will be heard, you will be taken seriously, and the U-M IOE community will stand behind you.
https://sites.google.com/umich.edu/report-concerns-and-misconduct/

Class Schedule

Date	Topic
Week 0	
10-Jan	Lecture 1: Fundementals & Single Parameter Models
Week 1	
17-Jan	Lecture 1: Fundementals & Single Parameter Models
Week 2	
24-Jan	Lecture 2: Single & Multiple Parameter Models
Week 3	
31-Jan	Lecture 3: Multiple Parameter Models & Numerics
Week 4	
7-Feb	Lecture 4: Numerics & MCMC
Week 5	
14-Feb	Lecture 5: MCMC & HMC
Week 6	
21-Feb	Midterm
Week 7	
28-Feb	Fall Break
Week 8	
6-Mar	Lecture 6: Heirarichal Models and Finished HMC
Week 9	
13-Mar	Lecture 7: Model Checking
Week 10	
20-Mar	Lecture 8: Gaussian process, Decision Analysis and BO
Week 11	
27-Mar	Lecture 9: Normal Approximations & Variational Inference
Week 12	
3-Apr	Lecture 10: Bayesian deep learning
Week 13	
10-Apr	Projects
Week 14	
17-Apr	Projects

University of Michigan
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13 out of 28 students responded to this evaluation.

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	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)	8	5	0	0	0	0	4.7	4.6	4.7
My interest in the subject has increased because of this course. (Q1632)	7	4	1	1	0	0	4.6	4.2	4.6
I knew what was expected of me in this course.(Q1633)	6	1	5	1	0	0	4.0	4.6	4.5
I had a strong desire to take this course.(Q4)	8	3	1	1	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	5	2	1	0	1	4.1	3.0	3.0

Responses to University-wide questions about the instructor:

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Raed Al Kontar seemed well prepared for class meetings.(Q230)	10	2	0	1	0	0	4.9	4.8	4.8
Raed Al Kontar explained material clearly.(Q199)	6	3	2	2	0	0	4.3	4.7	4.7
Raed Al Kontar treated students with respect.(Q217)	8	4	0	0	0	0	4.8	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)	6	3	2	2	0	0	4.3
Examinations covered the important aspects of the course. (Q356)	5	1	1	1	0	5	4.7

Responses to questions about the instructor:

	SA	A	N	D	SD	N/A	Your Median
Overall, Raed Al Kontar was an excellent teacher. (Q2)	7	3	2	1	0	0	4.6
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Date of Submission: 2024-03-12
Effective Term: Fall 2025

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	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Naval Arch & Marine Engin Subject: NAVARCH Catalog: 470	Dept (Home): Naval Arch & Marine Engin Subject: NAVARCH Catalog: 470
☐	☑ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number Manufacturing - MFG - 470	☑ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number Manufacturing - MFG- 470
☐	Course Title (full title) Foundations of Ship Design	Course Title (full title) Foundations of Ship Design
☐	Abbreviated Title (20 char) Ship Design	Abbreviated Title (20 char) Ship Design
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Organization of ship design. Preliminary design methods for sizing and form; powering, maneuvering, seakeeping estimation; arranging; propulsion; structural synthesis; and safety and environmental risk of ships. Extensive use of design computer environment. Given owner's requirements, students individually create and report the conceptual/preliminary design for a displacement ship.	
☐	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: Naval Arch & Marine Engin Catalog: 470

☐

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) NAVARCH 321, NAVARCH 332, NAVARCH 340. Co-req: NAVARCH 310.	Advisory Prerequisite (254 char) NAVARCH 321, NAVARCH 332, NAVARCH 340. Co-req: NAVARCH 310.
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑

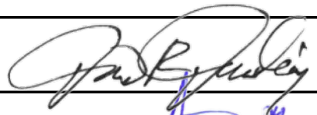
Course Components / Graded Component
- ☑ Lecture / ☑
- ☐ Seminar / ☐
- ☐ Recitation / ☐
- ☐ Lab / ☐
- ☐ Discussion / ☐
- ☐ Independent Study / ☐

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

Cognizant Faculty Member Name: Nickolas Vlahopoulos Cognizant Faculty Member Title: Professor

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

Contact Person: Email: Phone:

CoE Curriculum Committee Representative:		Print: Yulin Pan	Date: 4/10/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: David R. Dowling	Date: 4/4/24
Cross-Listed Department Chair:	ISD 	Print: Mihaela Banu	Date: 04/09/2024
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description Organization of ship design. Preliminary design methods for sizing and form; powering, maneuvering, seakeeping estimation; arranging; propulsion; structural synthesis; and safety and environmental risk of ships. Extensive use of design computer environment. Given owner's requirements, students individually create and report the conceptual/preliminary design for a displacement ship.	Course Description Organization of ship design. Preliminary design methods for sizing and form; powering, maneuvering, seakeeping estimation; arranging; propulsion; structural synthesis; and safety and environmental risk of ships. Extensive use of design computer environment. Given owner's requirements, students individually create and report the conceptual/preliminary design for a displacement ship.
Class Length Full term	Class Length Full term
Contact hours (lecture): 3	Contact hours (lecture): 4
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab) 2	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:
Removing LAB requirement to fit HLC compliance guidelines.

1210 LSA Building
500 S. State Street
Ann Arbor, MI 48109-1382
Phone: 734.763.2113
Fax: 734.936.3148
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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: 2024-07-08
Effective Term: Winter 2026

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

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Nuclear Engin & Radiolog Sci Subject: NERS Catalog: 250	Dept (Home): Nuclear Engin & Radiolog Sci Subject: NERS Catalog: 250
☐	☐ 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) Fundamentals of Nuclear Engineering and Radiological Sciences	Course Title (full title) Fundamentals of Nuclear Engineering and Radiological Sciences
☐	Abbreviated Title (20 char) Fund Nuc Eng/Rad Sci	Abbreviated Title (20 char) Fund Nuc Eng/Rad Sci
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Special relativity, basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle.	
☐	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: Nuclear Engin & Radiolog Sci Catalog: 250

☐	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) Preceded or accompanied by Math 216 and Physics 240. No OP/F. Minimum grade requirement: C	Enforced Prerequisite (254 char) Preceded or accompanied by NERS 320 and Physics 240. No OP/F. 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: Todd Allen Cognizant Faculty Member Title: Professor

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

Contact Person: Michelle Sonderman Email: mlwhit@umich.edu Phone: 734-936-3130

CoE Curriculum Committee Representative: Won Sik Yang Print: Won Sik Yang Date: 08/13/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Todd Allen Print: Todd Allen Date: 18 July 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 Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Special relativity, basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle.	Course Description Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Special relativity, basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle.
Class Length Full term	Class Length Full term
Contact hours (lecture): 4	Contact hours (lecture): 4
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:
Required for all students in BSE NERS program.

Special resources of facilities required for this course:

Supporting statement:
Updating the enforced prerequisites to ensure the success of students enrolled in the course.

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Course Approval Request Form

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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: 2024-07-18
Effective Term: Fall 2026

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

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Nuclear Engin & Radiolog Sci Subject: NERS Catalog: 311	Dept (Home): Nuclear Engin & Radiolog Sci Subject: NERS Catalog: 311
☐	☐ 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) Elements of Nuclear Engineering and Radiological Sciences I	Course Title (full title) Elements of Nuclear Engineering and Radiological Sciences I
☐	Abbreviated Title (20 char) N E & Rad Sci I	Abbreviated Title (20 char) N E & Rad Sci I
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics. Properties and structure of atoms.	
☐	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: Nuclear Engin & Radiolog Sci Catalog: 311

☐	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) Concurrent: NERS 320	Advisory Prerequisite (254 char) Concurrent: NERS 420
☐	Enforced Prerequisite (254 char) Physics 240. No OP/F. Minimum grade requirement: C	Enforced Prerequisite (254 char) Physics 240. No OP/F. 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: Zhong He Cognizant Faculty Member Title: Professor

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

Contact Person: Michelle Sonderman Email: mlwhit@umich.edu Phone: 734-936-3130

CoE Curriculum Committee Representative: Won Sik Yang Print: Won Sik Yang Date: 08/13/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Todd Allen Print: Todd Allen Date: 18 July 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 Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics. Properties and structure of atoms.	Course Description Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics. Properties and structure of atoms.
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:
Required course for all students in NERS BSE program.

Special resources of facilities required for this course:

Supporting statement:
Updating the advisory prerequisite to align with our new math sequence.

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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: 2024-07-16
Effective Term: Fall 2027

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

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Nuclear Engin & Radiolog Sci Subject: NERS Catalog: 441	Dept (Home): Nuclear Engin & Radiolog Sci Subject: NERS Catalog: 441
☐	☐ 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) Nuclear Reactor Theory I	Course Title (full title) Nuclear Reactor Theory I
☐	Abbreviated Title (20 char) Nucl React I	Abbreviated Title (20 char) Nucl React I
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) An introduction to the theory of nuclear fission reactors including neutron transport theory, the P1 approximation, diffusion theory, criticality calculations, reactor kinetics, neutron slowing down theory, and numerical solution of the diffusion equation.	
☐	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	
☐	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: Nuclear Engin & Radiolog Sci Catalog: 441

☐	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) NERS 312 and NERS 320 (No OP/F); or graduate standing. Minimum grade requirement: C	Enforced Prerequisite (254 char) NERS 312 and NERS 420 (No OP/F); 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: Won Sik Yang Cognizant Faculty Member Title: Professor

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

Contact Person: Michelle Sonderman Email: mlwhit@umich.edu Phone: 734-936-3130

CoE Curriculum Committee Representative: Won Sik Yang Print: Won Sik Yang Date: 08/13/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Todd Allen Print: Todd Allen Date: 18 July 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 the theory of nuclear fission reactors including neutron transport theory, the P1 approximation, diffusion theory, criticality calculations, reactor kinetics, neutron slowing down theory, and numerical solution of the diffusion equation.	Course Description An introduction to the theory of nuclear fission reactors including neutron transport theory, the P1 approximation, diffusion theory, criticality calculations, reactor kinetics, neutron slowing down theory, and numerical solution of the diffusion equation.
Class Length Full term	Class Length Full term
Contact hours (lecture): 4	Contact hours (lecture): 4
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:
Required course for all students in the BSE in NERS program.

Special resources of facilities required for this course:

Supporting statement:
Modifying enforced prerequisites due to the change in the required math sequence for the NERS BSE program

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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: 2024-07-16
Effective Term: Fall 2026

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

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Nuclear Engin & Radiolog Sci Subject: NERS Catalog: 484	Dept (Home): Nuclear Engin & Radiolog Sci Subject: NERS Catalog: 484
☐	☑ 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- 484	Biomedical Engineering- BIOMEDE- 484
☐	Course Title (full title) Radiological Health Engineering Fundamentals	Course Title (full title) Radiological Health Engineering Fundamentals
☐	Abbreviated Title (20 char) RHE Fundamentals	Abbreviated Title (20 char) RHE Fundamentals
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Fundamental physics behind radiological health engineering and topics in quantitative radiation protection. Radiation quantities and measurement, regulations and enforcement, external and internal dose estimation, radiation biology, radioactive waste issues, radon gas, emergencies, and wide variety of radiation sources from health physics perspective.	
☐	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	
☐	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: Nuclear Engin & Radiolog Sci Catalog: 484

☐

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 216 or MATH 256 or MATH 286. Minimum grade requirement: C	Enforced Prerequisite (254 char) NERS 320 or MATH 216 or MATH 256 or MATH 286; 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: Kimberlee Kearfott Cognizant Faculty Member Title: Professor

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

Contact Person: Michelle Sonderman Email: mlwhit@umich.edu Phone: 734-936-3130

CoE Curriculum Committee Representative: Won Sik Yang Print: Won Sik Yang Date: 08/13/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Todd Allen Print: Todd Allen Date: 18 July 2024

Cross-Listed Department Chair: Mary-Ann Mycek Print: Mary-Ann Mycek Date: 18 July 2024

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description Fundamental physics behind radiological health engineering and topics in quantitative radiation protection. Radiation quantities and measurement, regulations and enforcement, external and internal dose estimation, radiation biology, radioactive waste issues, radon gas, emergencies, and wide variety of radiation sources from health physics perspective.	Course Description Fundamental physics behind radiological health engineering and topics in quantitative radiation protection. Radiation quantities and measurement, regulations and enforcement, external and internal dose estimation, radiation biology, radioactive waste issues, radon gas, emergencies, and wide variety of radiation sources from health physics perspective.
Class Length Full term	Class Length Full term
Contact hours (lecture): 4	Contact hours (lecture): 4
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:
Selective course for BSE NERS program.

Special resources of facilities required for this course:

Supporting statement:
Updating enforced prerequisite to account for the math sequence change in the NERS BSE program.