UNIVERSITY OF MICHIGAN
College of Engineering
Curriculum Committee Meeting
Tuesday, April 9, 2024

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

Support Staff: Mercedes Carmona, Betsy Dodge, Matthew Faunce

Call to Order: 1:35 PM

Adjourned: 2:10 PM

Agenda:

1. Approval of 3.26.2024 Meeting Minutes – Page 3 - **APPROVED**
2. CSE CS-Eng Program Modification – Action Item – Page 7 – **APPROVED**
    a. The Computer Science and Engineering division of the EECS department was contacted to adjust the Computer Science (CS-Eng) Major Sample Schedule as this listed ROB 101 as a program substitution for MATH 214, which had not yet gone through the CoE Curriculum Committee for approval.
    b. Officially, the request is that ROB 101 be approved as a substitution for the linear algebra requirement for CS-Eng majors. The Robotics department has been in contact and is in approval with this course substitution for CS-Eng students. ROB 101 allows students to meet degree requirements as needed as MATH 214 may be at a max capacity and not allow students to take the course for the students' intended term. There is not an intention to change the sample schedule yet as most students take MATH 214 or 217, so the schedule will stay for now with an intention to apply changes for current and future CS-Eng students for Fall 2024, likely Winter 2025, effective term.
        i. A question is raised about what background does a student need to take ROB 101 and/or if the student needs to have an interest in Robotics or Computer Science?
            1. ROB 101 does not have any prerequisites. Taking this course earlier is beneficial for Computer Science students as it provides more mathematical grounding prior to the math/theory requirements that are specific to the Computer Science major.
                a. MATH 214 contains prerequisites and ROB 101 does not. Would any prerequisites need to be implemented for ROB 101?
                    i. CSE Department says if any prerequisites need to be included for the course, this will be discussed with the Robotics department and a modification CARF would be created for any changes needed.
        ii. Another inquiry about what coding is being presented in ROB 101?
            1. Robotics department states this is a 100-level course and the coding that is covered is included in the course description, Julia programming language.
        iii. If a department wanted to discuss similar changes, how are the departments involved communicating such as the course counting for another department's degree requirements?
            1. CSE contacted the ROB 101 instructors as well as the CoE Curriculum Committee Robotics department representative and began the discussion and understanding on how the course would need to be implemented for the department's degree requirements. Communication needs to take place so that all departments involved are on the same page.
                a. With the influx of EECS students taking ROB 101, would course topics or learning outcomes be altered in the future for CSE students rather than Robotics students? Are LSA CS-Eng students also taking ROB 101?

        i. CSE says there would need to be a discussion had with the Robotics department if the course material needed to be altered, but the current way ROB 101 is taught will stay the same.
        ii. LSA will not allow ROB 101 to be taken as a substitution for MATH 214 as Calculus II, MATH 116, is still needed as a course perquisite. Including LSA Students for ROB 101 would be a significant enrollment with further discussions needing to be had with all departments involved, Robotics, Mathematics, and CSE.
    c. CoE Curriculum Committee members voted unanimously to approve the program proposal. The proposal will appear at the next CoE Faculty meeting in Fall 2024.

3. Engineering Physics BSE Program Modification – Action Item – Page 9 – **APPROVED**
    a. The LSA Physics department has updated the course number and title for PHYSICS 351 – Methods of Theoretical Physics I to PHYSICS 316 – Mathematical Methods for Physics and Engineering. The department states this is a cosmetic change to try to encourage students to take the course earlier in their college career. This change will not have an impact on current students with the planned change to take effect in Winter 2025.
    b. CoE Curriculum Committee members voted unanimously to approve the program proposal. The proposal will appear at the next CoE Faculty meeting in Fall 2024.
4. MSE UG Minor Modification – Action Item – Page 11 - **APPROVED**
    a. Per undergraduate students, the current MSE Minor is “too easy” and lacks rigor for MSE students to be prepared for fundamentals concepts. To address these concerns, the MSE department proposes to modify the courses that fulfill the minor requirements, which also increases the minor credits from 17 to 19 credits.
        i. An issue is raised by the MECHENG and BIOMEDE departments due to MATSICE 330 and the coverage of Thermodynamics as some content may be repeated.
            1. There will be very little overlap as content covered for each course is as follows:
                a. BIOMEDE 221 = Coverage overlap of 3 weeks and the rest of the MATSCIE 330 content is different.
                b. MECHENG 335 = Coverage overlap of 2 weeks and the rest of the MATSCIE 330 content is different.
    b. CoE Curriculum Committee members voted unanimously to approve the program proposal. The proposal will appear at the next CoE Faculty meeting in Fall 2024.

CARF SUMMARIES

PAGE	SUBJECT	COURSE #	ACTION	SUMMARY	EFFECTIVE TERM	MIN. GRADE REQ. FOR ENF. PREPREQ	Is Course on LSA Course Guide?	APPROVED	NOTES & REVISIONS	TABLED
47	CEE	481	MOD	Change in Enforced Prerequisite.	WT 2025	C-	YES	APPROVED		
50	ECE	551	MOD	Change in Course Description and Advisory Prerequisite.	WT 2025	NO	YES	APPROVED		

UNIVERSITY OF MICHIGAN
College of Engineering
Curriculum Committee Meeting
Tuesday, March 26, 2024

Attending: Achilleas Anastasopoulos, Jeremy Basis, Robert Bordley, Marina Epelman, Chris Fidkowski, Fei Gao, Saadet Albayrak Guralp, Amir Kamil, Leena Lalwani, Xiaogan Liang, Frank Marsik, Radoslaw Michalowski, Eric Rutherford, Rachael Schmedlen, Ben Spector, Elyse Vigiletti, Roxanne Walker, Steve Yalisove

Support Staff: Mercedes Carmona, Betsy Dodge, Matthew Faunce

Call to Order: 1:35 PM

Adjourned: 2:53 PM

Agenda:

1. Approval of 3.12.2024 Meeting Minutes – Page 3 - **APPROVED**
2. CCC Email Vote for SI CARFs – Informational Item - Page 7
    a. Urgent email vote sent to CoE Curriculum Committee members for SI department CARFS cross listed with CSE that had the effective term listed as Fall 2024, which was confirmed with the University Registrar Office that these were okay to process after the Fall 2024 deadline dates.
    b. Issues raised by many members regarding the Course Description 80-word count limit being passed the requirement for both CARFs.
        i. Due to SI being the home department, this department does not need to abide by CoE CARF requirements. What is in M-Pathways for the Course Description, should reflect on the CARF and is also reflected on the Bulletin.
            1. Suggestion that future CARFs with non-CoE home departments cross listed with CoE departments are to abide by 80-word count limit or provide a shortened Course Description.
    c. Both CARFs were approved by members and sent to the URO for processing.
3. CLaSP in Applied Climate MEng Program Modification Proposal – Action Item – Page 14 - **APPROVED**
    a. Three changes are proposed to the program and the rationale is described below:
        i. Changing the name of the program to better reflect program content, MEng in Climate Impacts and Solutions.
            1. This name change is intended to attract more students and better reflect program content in engineering and distinguish U of M from all other programs.
            2. Question as to how this name change came to be and what other institutions have similar programs and what they're named.
                a. There were several institutions that were viewed with similar programs, such as Stanford, Columbia, Scripps Institution of Oceanography, and University of California Berkeley that focused on the social, policy, and management aspects but missed the engineering aspect. The most relevant program was Northeastern University which is situated in Civil and Environmental Engineering focused on aspects of adaption and mitigation.
        ii. Reducing the number of credits, 30 to 26, to allow the program to be completed in 2 semesters instead of 3 and be consistent with the other MEng programs offered.
            1. This change will make the program financially accessible to students. Incoming students are better prepared and do not need the 3-semester program anymore.
        iii. Revision of required courses and electives to provide a skill-based course schedule with greater flexibility.
            1. Proposed revision includes required core courses (10 credits), skill based elective courses (9 credits) and electives (7 credits).

b. The intended effective term for these changes is Fall 2025 with the new credit requirement being implemented in Winter 2026. Fall 2025 admitted students will be allowed to graduate under the new requirements.
c. CoE Curriculum Committee members voted unanimously to approve the program proposal. The proposal will appear at the next CoE Faculty meeting.

4. HLC Annual Audit Questions 3 & 4 for the CoE Curriculum Committee – Action Item – Page 18 - **APPROVED**
    a. Final review and vote of the Draft HLC Discussion Document to finalize revisions to the current CoE Credit Hour Policy.
        i. MATSCIE suggests adjusting "at least two to three hours" as this needs to be directly specified as this causes confusion for the faculty, staff, and students. Recommendations to change this to "two hours" or remove "at least" from the sentence.
            1. Most members are in favor of removing "at least" in the sentence to provide more clarity on the work outside of class.
        ii. IOE brings up the issue with seminar being included in the "Independent Study, Experiential and Seminar courses…" sentence as the information that follows is not always followed for seminar courses.
            1. EECS-CSE points out that seminar is included in the federal definition of the credit hour and is to be the 3 hours minimum. This is relied on by financial aid and accreditation. If a seminar course has less work to meet the credit hour policy, then the course should be adding more work so that the course is in compliance.
            2. MATSCIE follows up with how research should be included in this sentence as research is its own category and not always done independently as courses have group research.
                a. EECS-CSE states that on the CARF that Research is not a course component, but Independent Study is listed on the CARF and research, of any kind, should fall into this course component. If research is to be listed on the policy, Directed Research is what should be listed.
        iii. Suggestion of modifying "same total engagement requirements…" to specify course engagements.
            1. After some deliberation, this was revised to "same total academic work requirements…".
    b. After all final revisions and discussions were had, the committee voted unanimously to approve this final revised CoE Credit Hour Policy. This policy will be pushed to the next CoE Faculty Meeting, if needed for approval.
5. CoE/LSA Joint Meeting Agenda Items – Informational Item
    a. Are there any other topics worth discussing for this meeting?
        i. IOE brings up how CoE is to work with LSA on SUGS Programs, such as who does the review process, advising expectations. Overall, some type of agreement between CoE and LSA as to how to navigate these programs and to provide accurate information and/or assistance to students.

CARF SUMMARIES – TABLED from last meeting on 3.12.2024

PAGE	SUBJECT	COURSE #	ACTION	SUMMARY	EFFECTIVE TERM	MIN. GRADE REQ. FOR ENF. PREPREQ	Is Course on LSA Course Guide?	APPROVED	NOTES & REVISIONS	TABLED
21	CLIMATE	746	NEW		WT 2025	NO	NO	APPROVED	Cross listed with SPACE 746.	
35	CSE	598	MOD	Change in Course Components.	WT 2025	NO	YES	APPROVED		
38	ECE	510	NEW		WT 2025	NO	NO	APPROVED	Cross listed with NERS 675	
48	ECE	598	MOD	Change in Course Components.	WT 2025	NO	YES	APPROVED		
51	EECS	498	MOD	Change in Course Components.	WT 2025	NO	YES	APPROVED		
54	ENGR	101	MOD	Change in Credit Exclusions.	WT 2025	NO	YES	APPROVED		
57	ENGR	151	MOD	Change in Credit Exclusions.	FT 2025	NO	YES	APPROVED		
60	MATSCIE	506	NEW		WT 2025	NO	NO	CONDITONAL APPROVAL	Cross listed with CHE 506 and MACROMOL 506. Course Description needs adjustment.	
70	MATSCIE	509	NEW		WT 2025	NO	NO	CONDITONAL APPROVAL	Cross listed with BIOMEDE 509, CHE 509, and MACROMOL 509. Course Description needs adjustment.	

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
84	CEE	527	DEL		WT 2025	NO	YES	APPROVED		
87	CEE	527	NEW		WT 2025	NO	NO	APPROVED		

COLLEGE OF ENGINEERING
COMPUTER SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

AMIR KAMIL

UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
COMPUTER SCIENCE AND ENGINEERING

2260 HAYWARD STREET
ANN ARBOR, MI 48109-2121

April 2, 2024

Dear CoE Curriculum Committee:

I am writing on behalf of the Computer Science and Engineering (CSE) division to request that ROB 101 Computational Linear Algebra be approved as a substitution for the linear algebra requirement for CoE Computer Science (CS-Eng) majors. Many of our students already take ROB 101, and we believe that it is a valuable offering for our students to engage with linear algebra in the context of computation.

ROB 101 is designed to be a first-year course that introduces linear algebra along with applications in computation and robotics. Unlike the linear algebra courses in the Math department, ROB 101 does not require students to have prior knowledge of calculus, allowing students to take it concurrently with their calculus requirements. Despite this, the course successfully covers linear-algebra concepts at the depth needed for machine learning and robotics. Like MATH 214, it has written problem sets to give students practice at solving mathematical problems by hand. However, ROB 101 additionally has programming projects that put the concepts into practice, which is especially valuable for students in Computer Science. Atlas data show that while both classes have similar workload ratings (26% for MATH 214 vs. 24% for ROB 101), ROB 101 is significantly more well received by students:

Atlas Category	**MATH 214**	**ROB 101**
Desire to take	43%	**89%**
Understanding	82%	**96%**
Workload	**26%**	24%
Expectations	64%	**88%**
Increased interest	52%	**90%**

Atlas data also show that 40% of students in ROB 101 end up declaring CS-Eng, while another 9% declare CS-LSA. With an enrollment of about 400 students per year, this translates to 160 students a year for CS-Eng and an additional 35-40 students for CS-LSA.

CSE faculty who teach courses that require linear algebra have universally determined that ROB 101 meets the needs of Computer Science students. All CSE courses that have MATH 214 as a prerequisite (as well as nearly all such ECE courses) accept ROB 101 as an alternative:

- EECS 367 (ROB 380) Introduction to Autonomous Robotics
- EECS 442 Computer Vision
- EECS 445 Introduction to Machine Learning
- EECS 448 Applied Machine Learning for Modeling Human Behavior
- EECS 453 Principles of Machine Learning
- EECS 465 (ROB 422). Introduction to Algorithmic Robotics
- EECS 467 Autonomous Robotics Design Experience
- EECS 476 Data Mining

- CSE 576 Advanced Data Mining

Since ROB 101 does not have calculus as a prerequisite, students can make faster progress towards these courses by taking ROB 101 rather than waiting to take MATH 214 after completing the calculus sequence. In addition, taking linear algebra earlier is particularly beneficial to Computer Science students, as it provides more mathematical grounding prior to the math/theory requirements that are specific to the Computer Science major (one course each in probability and statistics, discrete mathematics, and theoretical foundations of Computer Science).

The addition of ROB 101 as an option for linear algebra does not yet require a change to the sample schedule for CS-Eng. At the current moment, the majority of our students take MATH 214 or 217 instead, so we will keep the existing schedule for now. We would like the addition to apply to both current and future CS-Eng students, with an effective term of Fall 2024.

Thank you for considering this modification. Please direct any questions to me and to Julie Tashjian (jbtash@umich.edu), who oversees the CS Undergraduate Advising Office.

Sincerely,

Amir Kamil
Chair of the Computer Science Undergraduate Program Committee
Lecturer IV, Computer Science and Engineering
University of Michigan
akamil@umich.edu

COLLEGE OF ENGINEERING
NUCLEAR ENGINEERING & RADIOLOGICAL SCIENCES
UNIVERSITY OF MICHIGAN

Todd Allen
Glenn F. and Gladys H. Knoll Department Chair
3001 Michigan Memorial Phoenix Project
2301 Bonisteel Boulevard *734-647-5845*
Ann Arbor, MI 48109-2104 *traumich@umich.edu*

2 April 2024

CoE Curriculum Committee
Subject: Modification of Engineering Physics B.S.E.

Dear CoE Curriculum Committee:

The Department of Nuclear Engineering & Radiological Sciences requests modification of the Engineering Physics B.S.E. degree program. Effective Winter 2025, the LSA Physics department will be updating the course # and title for Physics 351 (Methods of Theoretical Physics I), which is required for the Engineering Physics B.S.E. degree. The new course # and title will be: Physics 316 (Mathematical Methods for Physics & Engineering). The Physics department has stated that this is a cosmetic change to try to encourage students to take it earlier in their college career. This will not have an impact on our students. Beginning Winter 2025, students who have not yet completed Physics 351 will register for Physics 316 instead. We would like an effective date of Winter 2025.

Todd Allen
Professor and Chair
Department of Nuclear Engineering & Radiological Sciences
University of Michigan

Engineering Physics Sample Schedule

	Total Credit Hours	Term: 1	2	3	4	5	6	7	8
Subjects required by all programs (55 hours)									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Engr 100, Intro to Engr	4	4	-	-	-	-	-	-	-
Engr 101, Intro to Computers[1]	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211[2]	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241[3]	10	-	5	5	-	-	-	-	-
Intellectual Breadth	16	4	4	4	4	-	-	-	-
Advanced Mathematics (3 hours)									
Mathematics Electives (3 hours)[4]	3	-	-	-	-	-	-	3	-
Related Technical Subjects (8 hours)									
MATSCIE 250, Princ of Eng Materials or MATSCIE 220, Intr	4	-	-	4	-	-	-	-	-
EECS 314, Elect Cir, Sys, and Appl or EECS 215, Intro to Cir	4	-	-	-	4	-	-	-	-
Physics Technical Subjects (23 hours)									
Physics 340, Waves, Heat and Light	3	-	-	-	3	-	-	-	-
Physics 316, Mathematical Methods for Physics & Engineering[5]	3	-	-	-	-	3	-	-	-
Physics 390, Intro to Modern Physics or NERS 311, Ele of N	3	-	-	-	-	3	-	-	-
Physics 401, Int Mech[6]	3	-	-	-	-	-	3	-	-
Physics 405, Int Elect and Mag	3	-	-	-	-	-	-	3	-
Physics 406, Stat/thermal Physics	3	-	-	-	-	-	-	-	3
Physics Lab Elective or Directed Study with Research Lab	2	-	-	-	-	2	-	-	-
Physics Elective (300-level or higher)	3						3		
Engineering Concentration (20 hours)[7]									
Engineering Electives	16	-	-	-	-	4	4	4	4
Engineering Laboratory Elective (400-level or higher)	4	-	-	-	-	-	-	-	4
Technical Electives (7 hours)[8]									
Mathematics, Physics or Engr Courses (300-level or higher	7	-	-	-	-	-	4	3	-
General Electives (12 hours)	12	-	-	-	-	3	3	3	3
Total	128	17	17	17	15	15	17	16	14

Revised 4-2024 effective WN 2025

Candidates for the Bachelor of Science in Engineering in Engineering Physics - B.S.E. in Eng Physics - must complete the program listed above. This sample Notes:

1. EECS 180 credit (Exam/Transfer Introductory Computer Programming) will not meet the programming requirement on its own. Students must also select from Engr 190-002, Engr 101, Engr 151, or EECS 280.
2. If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for CoE.
3. If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and 240/241 you will have met the Physics Core Requirement for CoE.
4. Math Electives must be 300-level or higher.
5. NERS 320 can be used as a subsitute, as well as possibly other similar courses, subject to Undergraduate Chair approval.
6. For students pursuing ME in Engr Technical Elecives, CEE 211 or ME 240 will be advised as a substitute for Physics 401. MECHENG 440 or MECHENG 540 can be substituted with faculty program advisor approval.
7. Engineering Electives are to be chosen in consultation with the Undergraduate Chair to form a coherent sequence that clearly defines professional goals for the student. Sample elective sequences for a number of different subject areas are available from the academic or faculty advisors.

8 .Students contemplating graduate studies in Physics should elect Physics 453, Quantum Mech and Physics 463, Solid State for a complete background.

COLLEGE OF ENGINEERING
MATERIALS SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

April 2, 2024

Dear Curriculum Committee,

We are writing to request approval of the following modifications to the minor program in the Department of Materials Science and Engineering (MSE) with an effective start date at the beginning of the Winter 2025 semester. These modifications are in response to comments raised by undergraduates regarding a perceived lack of rigor, and concerns raised by the MSE faculty regarding the minor program and students' inadequate preparation in fundamental concepts in MSE.

Feedback from undergraduate students indicates that the current minor program in MSE is perceived as "too easy", that is, lacking in required coursework (described below). This is likely the reason why the minor program has become nearly as large as the major program. We have a total of 69 students currently declared in the minor program, and that figure continues to increase steadily. This number may soon reach the number of students declared in the major program (currently 98).

The second major concern is the lack of preparation in the field of MSE for students in the minor program. To earn a minor in MSE, a student must currently take a minimum of 17 credits distributed among five courses. Two of the five courses are required (MATSCIE 220/250 "Introduction to Materials" and MATSCIE 350 "Structures of Materials"), while the remaining three courses are selected from a published list of technical electives.[1] Unfortunately, these requirements do not encompass thermodynamics and kinetics. As a result, students lack a depth of understanding in these two "pillars" of our discipline. Indeed, a review of the contents of thermodynamics and kinetics courses as taught in other Engineering Departments (see reference syllabi) shows that fundamental MSE content is not covered in these courses. Missing topics include the development and interpretation of alloy phase diagrams from Gibbs free energies and atomistic mechanisms of diffusion and phase transformation in crystalline materials.

To address these concerns and ensure that our minor program adequately prepares students in MSE, we propose modifying the courses that fulfill the requirements of the minor. The student will need to take MATSCIE 330 "Thermodynamics of Materials" and MATSCIE 335 "Kinetics and Transport" in addition to MATSCIE 220/250 and MATSCIE 350 (as before). For the fifth course, the student is recommended to take MATSCIE 242 "Physics of Materials" in most cases;[2] however, they are free to substitute this course with another that may be better aligned with their interests and career goals, depending also on their major (see Table 1). The minimum number of credits is increased to 19.
We believe that these modifications will better align the minor program in MSE with the goals of our department, ensuring that students graduate with the necessary knowledge and skills to excel in MSE.

We thank you for your consideration and look forward to any feedback.

Sincerely,

Ashwin Shahani, on behalf of the MSE Undergraduate Committee

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[1] See https://mse.engin.umich.edu/undergraduate/programs/minor.
[2] Students from ChE, Eng. Physics, EE, and NERS should not take MATSCIE 242 since there is an equivalent course on materials physics and quantum mechanics in their home department.

COLLEGE OF ENGINEERING
MATERIALS SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

Table 1. Course requirements for the minor in Materials Science and Engineering showing required courses and approved substitutions for MATSCIE 242 depending on the student's major.

Major	220/250	242	350	330	335	400	410	412	420	440	454	465	470	514
Aero	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	X
BME	✓	(✓)	✓	✓	✓	SUB	X	SUB	SUB	SUB	SUB	SUB	SUB	SUB
ChE	✓	X	✓	✓	✓	SUB	SUB	X	(✓)	SUB	SUB	SUB	SUB	SUB
Civil	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	X
Climate and Meterorology	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB
Comp Sci	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB
Comp Eng	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB
Data Sci	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB
Eng. Physics	✓	X	✓	✓	✓	SUB	SUB	SUB	(✓)	SUB	SUB	SUB	SUB	SUB
EE	✓	X	✓	✓	✓	X	SUB	SUB	(✓)	SUB	SUB	SUB	SUB	SUB
Environmental	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB
IOE	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB
ME	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	X	SUB	SUB	SUB	SUB	X
NAME	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB
NERS	✓	X	✓	✓	✓	SUB	SUB	SUB	(✓)	SUB	SUB	SUB	SUB	SUB
Robotics	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB
Space Sci	✓	(✓)	✓	✓	✓	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB

Key:
✓ = required
(✓) = recommended, but may be substituted by an MSE course denoted by SUB
SUB = valid Substitution
X = not a valid substitution

AERO 225: Introduction to Gasdynamics

Winter 2024

Professor Chris Limbach, 3021 FXB (Aero), limbach@umich.edu

Class Culture

I am Professor Limbach, and my pronouns are he/him/his. Please feel free to contact me with anything you would like me to know about how you would like to be addressed in this class. It is my hope that every student in this course gets what they need to learn the most they can. I am committed to a class culture that welcomes and serves students of all ages, ethnicities, genders, gender identities and expressions, national origins, religious affiliations, sexual orientations, and socioeconomic backgrounds - and other visible and nonvisible differences. I will work to foster a respectful, welcoming, and inclusive environment, and will expect each student to contribute as well. Your suggestions are encouraged and appreciated. For diversity, equity, and inclusion resources, please check: https://aero.engin.umich.edu/info/dei-resources/

Meets In-person MoWe 10:30 AM – 12:00 PM in 1109 FXB.

Instructor Professor C.M. Limbach, 3021 FXB
Office Hours: Wednesday 1pm – 2pm

GSI Nicholas Diskerud (diskerud@umich.edu)
Office Hours: Twice per week: poll to be sent out over Canvas

Grader TBD
Office Hours: TBD; Aero Learning Center

Canvas Web Site

- Important Source of required and supplementary material.
- Lecture recordings, assignments, announcements, quizzes, etc.
- Homework will be submitted by upload to Canvas.
- Check it frequently for updates.

Resources

- Primary Textbook: J.D. Anderson, *Modern Compressible Flow with Historical Perspective.* 3rd ed. McGraw-Hill 2003

  I have listed two books that are available free electronically through the University Library website; both are recommended supplementary reading:
  - Modern Engineering Thermodynamics, Balmer
  - Gasdynamics: Theory and Applications, Emmanuel

  For those desiring a hardcopy book, I also recommend:
  - Modern Compressible Flow, Anderson
  - Mechanics and Thermodynamics of Propulsion, Hill and Petersen
  - Elements of Gasdynamics, Liepmann and Roshko

  Dr. Powell has generously provided his typed notes for this course. They cover the first two-thirds of the course. I will work to try to find an alternative note source for the remainder, but you should not expect printed notes for the last third of the class: the Emmanuel text, lecture slides and the notes you take in lecture will need to be your resources.

Homework Submission

Due at specified dates and times through upload on Canvas. Check deadlines carefully. Upload a version early just in case you miss the deadline. Upload as a single PDF file.

Homework Specifications

- Homework must be neat and professional in appearance. No cross outs may appear anywhere. *The grader will not grade excessively messy homework.*
- Use a ruler to draw lines neatly. Plots should be properly formatted: axis labeled correctly, font large enough to read, use line/symbol and color/shapes to show results.
- You may type your homework if you want, but that isn't necessary.
- Explain the reasoning behind your calculations. Describe what you are solving and how you do it, not simply lines of equations. Credit is given for the method as well as the answer.
- To help the graders, please put your final answer in a box. Always include units if appropriate.

Homework Warnings

- Late homework will not be accepted unless a reasonable and verifiable excuse is presented.
- Very messy homework will not be graded after the first warning.
- Conceptual discussion is allowed. However, all substantive work must be your own.
- All computer code must be your own.
- The use of homework solutions from past courses is not allowed.
- *Any violation of this policy will be reported to the honor council for investigation and adjudication.*

Honor Code and Collaboration Policy

- All students in Aero 225 are presumed to be decent, honest people, and to abide by reasonable standards of conduct.
- Collaboration on homework is permitted and encouraged. Any collaboration must be explicitly acknowledged. (For example, "On problems 2 and 3, I collaborated with Marie Curie. She was very helpful") Collaboration should be at the conceptual level; each student should work through and write up each assignment without looking at the work of other students.

Examples of acceptable collaboration:

- Discussing the general approach to a problem, including relevant theorems/equations.
- Comparing intermediate and final answers after finishing a problem

Examples of unacceptable collaboration:

- Turning in a photocopy or an identical printout of a problem write-up, Matlab plot, Matlab code etc.

- Looking at another student's code or problem write-up prior to completing a problem on your own.
- Allowing another student to look at your code or problem write-up.

Grading:

Grading:	Homework	55%
	Midterm Exam	20%
	Final Exam	20%
	Quizzes	05%
	Total	100%

On homework, a point scale will be used to facilitate grading but all homework assignments will count equally as a percentage of the homework grade.

As a baseline, a straight scale will be used for letter grade assignments:
A+/A/A-: 100–97–92–90, B+/B/B-: 90–87–82–80
C+/C/C-: 80–77–72–70, D+/D/D-: 70–67–62–60 E: < 60

The application of a curve will be at the discretion of the instructor, and applied at the end of the term. Any curve will be linear (+X% for everyone) and only positively impact your grade.

Course Evaluation

I will add 3*(% of submitted midterm and final evaluations) to everyone's score. For example, assuming 73 students in the class, if 36 submit the midterm evaluation and 44 submit the final evaluation, then I will add 3*(36+44)/146 = 1.64 points to everyone's final score.

Computing and GPTchat or Similar

Python codes will be made available during the course. These are provided as a courtesy and you may be required to write your own code on certain assignments and/or if you choose to work in a different computing language.

Use of GPTchat is permitted for homework and studying, but not for completing homework problems wholesale. For example, you are permitted to ask questions such as "Can you describe the Mach-area relation as it applies to nozzle flow?" but not "Solve problem 1b: If a weak shock wave is observed at a Mach angle of 40 degrees, what is the Mach number?". Endeavor to use AI tools as a study aid and not develop a dependence.

Desired Course Outcomes
My hope/expectation is that you will be able to do the following on completion of this course:

Gas properties
(1) Recall the distinguishing factors of solids, liquids, gases and plasmas
(2) Use the perfect gas equation of state
(3) Be able to account for real-gas effects using the compressibility factor and Van der Waals equation
(4) Describe the significance of the phase-space distribution in kinetic theory
(5) Recall the specific heats for monatomic, diatomic and polyatomic gases
(6) Be able to determine when the continuum hypothesis is valid

Thermodynamics

(1) Define systems, control volumes, states, processes and cycles
(2) Define heat and work
(3) Calculate the work due to isothermal, isobaric and isochoric processes
(4) Use the First Law to relate energy changes to work and heat
(5) Explain the meaning of energy and enthalpy
(6) Use the Second Law to relate heat and temperature to entropy change
(7) Explain the meaning of entropy
(8) Determine whether processes are reversible or irreversible
(9) Calculate the entropy change between two states defined by any two independent properties
(10) Construct $p - v$ and $T - s$ diagrams for various processes

Conservation laws
(1) Define control volumes, control surfaces and flux
(2) Apply conservation of mass for steady and unsteady one- and two-dimensional flows
(3) Describe the forces that can act on a fluid element
(4) Apply conservation of momentum for steady one- and two-dimensional steady flows
(5) Apply conservation of energy for steady one-dimensional flows

Special Properties in Compressible Flow
(1) Derive the differential forms of mass, momentum, energy and entropy conservation from a control-volume analysis
(2) Calculate the acoustic speed and Mach number
(3) Derive basic isentropic relations
(4) Define and calculate static and stagnation quantities
(5) Explain how a Pitot probe works

Normal Shocks
(1) Derive the normal shock jump relations from a control-volume analysis
(2) Apply the jump relations to calculate downstream quantities from upstream quantities for a normal shock
(3) Explain the limiting forms of the jump relations for very weak and very strong normal shocks
(4) Derive the oblique-shock jump relations by a control-volume analysis
(5) Apply the jump relations to calculate downstream quantities from upstream quantities for an oblique shock

Constant Area Flow with Heat Addition
(1) Plot the Rayleigh line for a flow, and explain its significance
(2) Calculate the change in flow properties due to heating/cooling, using graphical, tabular and code techniques
(3) Explain thermal choking
(4) Describe quantitatively the changes in flow properties due to heating or cooling a subsonic or supersonic flow

Constant Area Flow with Friction
(1) Plot the Fanno line for a flow, and explain its significance
(2) Calculate the change in flow properties due to friction, using graphical, tabular and code techniques
(3) Explain frictional choking
(4) Describe quantitatively the changes in flow properties due to friction in a subsonic or supersonic flow

Variable Area Adiabatic Flow
(1) Explain the limits on the quasi-one-dimensional flow approximation
(2) Describe qualitatively how subsonic and supersonic flows behave in converging and diverging sections
(3) Calculate the variation of flow properties for isentropic with area change by tabular, graphic and computational methods
(4) Explain choking due to area restriction
(5) Calculate the maximum mass flow for a rocket nozzle
(6) Explain when shocks occur in area-change flow, and how they affect the flow

2D Flow Oblique Shocks
(1) Calculate the reflection angle for an oblique shock reflecting from a wall
(2) Use matching conditions to calculate reflection angles and properties at shock interactions

2D Flow Expansion Waves
(1) Calculate the angle between leading and trailing waves in an expansion fan
(2) Calculate the downstream values from the values upstream of an expansion and the turning angle

Student Mental Health
It is common for students to experience any of a number of things that can be a barrier to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating, and lack of motivation. The department and university are committed to advancing the mental health and well-being of our students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. You can learn more about the range of confidential services available at: https://caps.umich.edu/mitalk.

Other Resources
- Academic, financial, and wellness support: CARE center (https://care.engin.umich.edu)
- Network and computer support: CAEN (https://caen.engin.umich.edu),
- Aero Tech Center (David McLean, dmclean@umich.edu)
- Free aero tutoring (SGT, sgt-academic@umich.edu)

AEROSP 325: Aerodynamics

Winter 2024

Lectures:	Mon., Wed. noon-1:30pm, 1109 FXB
Instructor:	Prof. Krzysztof Fidkowski (kfid@umich.edu)
Office Hours:	Wed. 2:30-4pm, Thur. 1-2:30pm (Aero Learning Center)
IA1:	Eamonn Reilly (eareilly@umich.edu)
IA1 Office Hrs:	Thur. 4:30-6:30pm, Fri. 2-5pm (Aero Learning Center)
IA2:	Dennis Serbin (dserbin@umich.edu)
IA2 Office Hrs:	Tues. 4-5:30pm, Fri. 2-5pm (Aero Learning Center)
Course website:	Canvas: `https://umich.instructure.com`
Resources:	Notes/codes on course website

Description:

This course covers fundamental concepts in aerodynamics. Students learn about the governing equations of fluid dynamics, with emphasis on inviscid and incompressible flow. Equations and physical concepts are used to show how airfoils produce lift and how the pressure distribution about an airfoil can be calculated. Introduces the boundary-layer concept, how boundary layers lead to drag and what makes them prone to instability and turbulence or separation. Additional topics include finite wing theory, which addresses the three-dimensional shapes of wings, and compressible flow, which addresses the effects of high-speed flight, including supersonic flow.

Lectures and Office Hours

Lectures will be given in-person, and attendance is strongly encouraged. As a contingency for unexpected absences, the lectures will be simultaneously streamed on Zoom using the classroom Zoom computer, and interactive participation via Zoom will be possible. The lectures will be recorded and made available on the course website shortly after they are given. The material covered in the lectures will be used to formulate questions for homework and exams.

Prof. Fidkowski will be holding office hours in-person to answer questions from individuals and groups. The IAs will be holding separate office hours for answering questions and helping with assignments. You are welcome to attend all, some, or none of the office hours sessions.

Piazza:

We will use Piazza, linked through Canvas, as the primary question and answer medium. You can post your questions and/or answer other students' questions. The instructors will be monitoring and responding continuously.

Textbook and Materials

- Typed notes available on Canvas.
- *Fundamentals of Aerodynamics.* (4th+ ed). J. D. Anderson Jr. McGraw Hill. (*optional*)

Grading

- There will be **11 homework assignments**, generally due on Fridays and posted a week in advance. The lowest homework grade will be dropped in the calculation of the final grade.
- There will be **11 reading quizzes**, generally due Wednesdays and posted a few days in advance. These will be timed multiple-choice and true/false Canvas quizzes. The lowest quiz grade will be dropped in the calculation of the final grade.

- There will be **3 in-class, on-paper, in-person exams**. Each exam will consist of a combination of true-false, multiple-choice, and free-response problems. Attendance for the exams is mandatory. Requests for special accommodations must be made at least one week in advance.

The final grade will be determined using the following breakdown:

Homework	30%
Reading quizzes	15%
Exam 1	15%
Exam 2	20%
Exam 3	20%

Grading will be based on a straight scale:

E: < 60 D: 60–70 C: 70–80 B: 80–90 A: 90–100

Grade modifiers (+/−) will be used with delineations at the instructor's discretion, but roughly in a 3/4/3 split: e.g. A- for 90-93, A for 93-97, A+ for 97-100. If deemed necessary by the instructor, individual exams may be curved. *Requests for re-scoring of assignments or exams must be made in writing, using the comment feature in Canvas.*

Assignment Submission

- All assignments must be uploaded electronically to the course website, Canvas. Scanned hand-written documents are acceptable and must be legible. If scanning with a phone or tablet, do not upload raw images; instead, use a scanning app that produces clear pdf files, and ensure that the document is of sufficient resolution before uploading.
- Note the due date and *time* indicated on each assignment. Late homework will be marked down 1% for each hour that it is late. No late homework will be accepted once solutions are posted, which will in general be 72 hours after the due time.
- Each student has two extension days that they can apply to homework assignments. These extensions can be used as two 24-hour extensions or one 48-hour extension (not possible before all exams). To apply an extension to an assignment, please email both IAs, with "AEROSP 325" included in the subject line, noting the assignment and extension length (one or two days). You must declare extensions before the assignment due date, and you cannot request partial-day extensions. Additional days beyond the given extension block will be considered in documented emergency situations, if you have already used up your block. Such requests must be made to the IAs.

Honor Code and Collaboration

All students in Aero 325 are presumed to abide by reasonable standards of conduct. All exam work must be carried out completely on your own, without aid from any of your fellow students. Exams will be closed book. The only notes allowed to be brought to the exams may be on double-sided 8.5 × 11 sheets prepared by you in anticipation of the exam (1 sheet for each exam). You are expected to sign the honor code on all exams. Collaboration on homework is permitted at the conceptual level, but each student must work through and write up each assignment without looking at the work of other students. Examples of **acceptable** collaboration include discussing the general approach to a problem, including relevant theorems and equations; comparing intermediate and final answers after finishing a problem. Examples of **unacceptable** collaboration include turning in identical work or looking at another student's work prior to completing a problem on your own. You are expected to abide by any special instructions given for any assignment or exam.

Computers and Programming

Some homework problems will require making computer-generated plots, using numerical software packages (e.g. for solving a linear system), and/or writing short computer programs. Although the software/language choice is up to you, most students find Matlab the easiest to work with. Matlab will also be used for sample codes and in-class demonstrations. If you need help with such assignments, please seek it early from the instructors.

Getting Help

We will be covering a lot of material in this course. You are strongly encouraged to seek any required help from your instructors with any aspect of the assignments. You are also strongly encouraged to seek them out for help understanding basic concepts from the course. Posting well-posed questions to the course Q&A site (Piazza) can be an effective way to get help quickly.

Reading and Quizzes:

On the Canvas website you will find typed notes with the course material. This is required reading, and the relevant sections for each week are given on the calendar at the end of the syllabus. You will have quizzes via Canvas on the relevant readings. Lecture material may also be covered on the quizzes. These will be multiple-choice questions, to be completed on your own time before 11:59pm on the due dates indicated on the calendar. The calendar also indicates the reading sections associated with each quiz.

Inclusion:

We, the instructors, hope that every student in this course has every opportunity to get what they need out of the course. We are committed to a class culture that welcomes and serves students of all ages, ethnicities, genders, gender identities and expressions, national origins, religious affiliations, sexual orientations, socioeconomic backgrounds, and other visible or hidden differences. We will work to foster a respectful, welcoming, and inclusive environment, and we will expect each student to contribute as well. Your suggestions are encouraged and appreciated.

Mental Health:

It is common for students to experience a number of conditions that can impede learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating, and lack of motivation. The department and university are committed to advancing the mental health and well-being of our students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. You can learn more about the range of confidential services available at: `https://caps.umich.edu/mitalk`.

Other Resources:

- Academic, financial, wellness support: CARE center (`https://care.engin.umich.edu/`)
- Network and computer support: CAEN (`https://caen.engin.umich.edu/`, Aero Tech Center (David McLean, `dmclean@umich.edu`)
- Free aero tutoring: SGT (`sgt-academic@umich.edu`)

Measurable Outcomes

I. Introduction

(1) Analyze validity of vector expressions.
(2) Apply Gauss's and Stokes' theorems in two and three dimensions.
(3) Transform differential and integral expressions to cylindrical coordinates.
(4) Recall basic thermodynamics relations.

II. Kinematics

(1) Define the material derivative and explain Eulerian and Lagrangian reference frames.
(2) Explain differences between pathlines, streamlines, streaklines, and timelines.
(3) Apply conservation of mass in integral and differential form.
(4) Analyze incompressible, irrotational flow using a streamfunction and velocity potential.
(5) Calculate vorticity and rate-of-strain tensors for a given velocity field.
(6) Relate angular velocity, shear strain, and normal strain to the rotation and deformation of a fluid element.
(7) Explain the relationship between vorticity and circulation.

III. Dynamics

(1) Apply conservation of momentum in integral and differential form.
(2) Set up and solve 2D problems involving the incompressible Navier-Stokes equations.
(3) Use Bernoulli's equation to relate pressure, velocity, and altitude.
(4) Explain the generation of lift on an airfoil using flow turning and streamline curvature.

IV. Potential flow

(1) Analyze incompressible, irrotational flows using the complex potential.
(2) Superimpose elementary complex potentials and apply the method of images.
(3) Explain the relationship between circulation and lift via the Kutta-Joukowski theorem.
(4) Define the coefficient of pressure and calculate it for elementary potential flows.

V. Thin-airfoil theory

(1) Be familiar with the basic terminology of airfoil theory.
(2) Explain the Kutta condition.
(3) Sketch and explain a typical pressure distribution on an airfoil, with emphasis on the leading-edge region and the effects of camber and thickness.
(4) Explain the difference between the center of pressure and the aerodynamic center.
(5) Analyze the performance of an airfoil using the equations of thin airfoil theory.
(6) Use thin airfoil theory to design camberlines that meet specific requirements, such as static stability and no leading-edge suction peak.
(7) Understand the assumptions and limitations of thin airfoil theory.
(8) Explain the *basic elements* (see comment below) of the vortex panel method.

VI. Boundary layers

(1) Explain the conditions under which a boundary layer is present, with reference to viscosity, the Reynolds number, and boundary conditions.

(2) Define the wall shear stress and the skin friction coefficient.
(3) Explain the assumptions of the boundary layer equations.
(4) Apply the Blasius solution to calculate properties of a laminar boundary layer.
(5) Explain the concept of a similarity solution in the context of boundary layers.
(6) Calculate the skin friction drag on a flat plate in 2D and 3D, accounting for the possibility of laminar to turbulent transition.
(7) Describe laminar boundary layer separation and the factors that contribute to it.
(8) Explain the onset of turbulence in a boundary layer (i.e. transition) and the qualitative effects of turbulence on boundary layer evolution including the impact on velocity profile, skin friction coefficient, boundary layer thickness, and separation.

VII. Finite-wing theory

(1) Apply the Biot-Savart law to compute the velocity induced by a vortex filament.
(2) Define wing aspect ratio, taper ratio, span, twist, and sectional camber.
(3) Explain the *basic elements* of Prandtl's lifting line theory.
(4) Describe downwash and how it relates to induced drag.
(5) Explain the point-collocation method for solving Prandtl's lifting line equation.
(6) Apply Prandtl's lifting line equation to solve for the forces on a given wing geometry.
(7) Use Prandtl's lifting line equation to design wings that meet specific requirements, such as minimum induced drag.
(8) Understand the properties of an elliptic lift distribution.
(9) Define the lift curve slope and factors that affect it.
(10) Explain the benefits of ground effect and formation flight.
(11) Explain the *basic elements* of 3D vortex lattice methods.

VIII. Compressible flow

(1) Explain the differences between subsonic (subcritical), transonic (supercritical), and supersonic flow regimes.
(2) Describe the difference in character in the linearized compressible potential flow equation between subsonic and supersonic flight.
(3) Explain the Prandtl-Glauert correction, including the effect of Mach number on c_p and the lift curve slope.
(4) Calculate the critical Mach number for an airfoil.
(5) Use the method of characteristics to solve the supersonic small-disturbance potential flow equations, including the calculation of lift and drag on an airfoil in supersonic flow.

Comment on basic elements: The basic elements of a model include the critical features that produce a valuable predictive method. For example, the basic elements of a 2D panel method would include: all of the underlying assumptions of incompressible, potential flow; the discretization of an airfoil geometry into a set of line segments on which potential flow solutions are distributed; the satisfaction of flow tangency at panel control points; the global influence of an individual panel on all other panels; the imposition of the Kutta condition; etc. However, the basic elements would not include the more detailed aspects of the method which, while important, are not critical to understanding how the method works. In the 2D panel method example, it would not include the details of the calculation of the influence coefficient of a general source/vortex/doublet panel; the solution of the large linear system of equations; etc.

Schedule

Due dates for homework, quizzes, and exams. Reading chapters refer to the course notes provided on Canvas, and the corresponding quiz number is given with each reading assignment. Unless otherwise stated, all due times will be 11:59pm.

Week	M	T	W	Th	F	Topics	Readings
Jan 08			SciTech			Introduction	*1 (Q1)*
Jan 15	MLK		Quiz 1		**HW1**	Kinematics	*2 (Q2)*
Jan 22			Quiz 2		**HW2**	Dynamics	*3 (Q3)*
Jan 29			Quiz 3		**HW3**	Potential Flow	*4 (Q4)*
Feb 05			Quiz 4		**HW4**	Potential Flow	*1-4 Review*
Feb 12			**Exam 1**			Thin airfoil theory	*5.1 – 5.3 (Q5)*
Feb 19			Quiz 5		**HW5**	Thin airfoil theory	*5.4 – 5.6 (Q6)*
Feb 26	Winter Break						
Mar 04			Quiz 6		**HW6**	Boundary Layers	*6.1 – 6.3 (Q7)*
Mar 11			Quiz 7		**HW7**	Boundary Layers	*6.4 – 6.6 (Q8)*
Mar 18			Quiz 8		**HW8**	Boundary Layers	*5,6 Review*
Mar 25			**Exam 2**			Finite-wing theory	*7.1 – 7.2 (Q9)*
Apr 01			Quiz 9		**HW9**	Finite-wing theory	*7.3 – 7.4 (Q10)*
Apr 08			Quiz 10		**HW10**	Compressible flow	*8 (Q11)*
Apr 15			Quiz 11		**HW11**	Compressible flow	*7,8 Review*
Apr 22	**Exam 3**						

CHE 330: Chemical and Engineering Thermodynamics
Course Syllabus

Primary Instructor: Professor Rebecca Lindsey
Lecture Times: MWF, 11:30 to 12:30
Lecture Location: Bob and Betty Beyster Building, Room 1670

Teaching Team:

Name	Role	Email	Office Hours (OH) Time*	OH Location*
Prof. Lindsey	Instructor	rklinds@umich.edu	Wed. 12:30-1:30p Fri. 12:30-1:30p	Dow 3216 Zoom
Aarti Mathur	GSI	aartim@umich.edu	Tues. 9:30-10:30a Wed. 5:30-6:30p	Dow 3216 Zoom
Seun Akanbi	GSI	oakanbi@umich.edu	Mon. 4:00-500p Tues. 2:30-3:30p	Zoom Dow 3074G**
Nolan Lysaght	IA	nlysaght@umich.edu	Thurs. 3:00-5:00p	Dow 3216
Asesh Chanda	IA	aseshc@umich.edu	Monday 9:30-10:30a Thurs. 12:30-1:30p	Dow 3216 Zoom
Sophia Lee	Tutor	sophiia@umich.edu	Tues. 5:30 – 6:30p Fri. 1:30-2:30p	Zoom EECS 1008

**Office hours time/location subject to change*
***Room Dow 3212 on 1/23 & 4/16*

A Note on Correspondence:

We receive a deluge of e-mail each day. To ensure yours doesn't slip through the cracks, **please begin the subject line of your email correspondence to us with "W24 CHE330"**. Please also be sure to include your name in the e-mail body so we know with whom we are corresponding!

Course Description:

This course explores fundamentals of thermodynamics and how they can be combined with concepts learned in Material and Energy Balances (CHE 230) to develop chemical engineering processes. Upon successful completion of this course, you will be able to:

- Explain the molecular basis of thermodynamics
- Calculate thermodynamic properties using equations of state, charts and tables, and computer resources
- Solve problems dealing with multi-phase chemical systems and reactive systems
- Apply the laws of thermodynamics to chemical engineering processes
- Interpret thermodynamic data for applications in chemical engineering processes, and process safety

All individuals are welcome and can expect to be treated with respect, regardless of race, color, national origin, age, marital status, sex, sexual orientation, gender identity, gender expression, disability, religion, height, weight or veteran's status, and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive classroom.

Textbook:

We will be using the SI Edition of *Fundamentals of Chemical Engineering Thermodynamics* by K.D. Dahm and D.P. Visco. Note: "SI Edition" refers to units used throughout the book!

Classroom Technology:

Homework assignments, grades, and discussion forums will all be handled electronically, through Canvas, Gradescope and Piazza, respectively.

Canvas: Canvas can be accessed by searching for "Canvas" on the Wolverine Access website.
Lecture notes will be posted on canvas no later than the night before each class, under the "Files" link

Gradescope: Gradescope is an online platform for assignment submission. Access via the course Canvas page.

Piazza: Piazza is a forum for anonymous student questions and answers. Everyone benefits when you post on Piazza, especially since many other may have the same question; when it's answered on Piazza, it's answered for everybody! Participation is rewarded (see Grading section below). **Post questions to Piazza instead of emailing instructors directly.** Interactions are expected to be respectful, just as in a classroom setting Students are expected to adhere to the honor code (concepts are ok to discuss, numbers are not). Access via the course Canvas page.

Sign up at: https://piazza.com/umich/winter2024/che330001wn2024

Tentative Course Schedule:

Note: this schedule is subject to change based on pacing.

Lecture	Date	Week	Day	Chapter	Topic	Posted HW	HW Due
1	1/10/24	1	Wed.	1	Course Overview & Introduction		
2	1/12/24	1	Fri.	1	Introduction		
	1/15/24	2	Mon.		**No Class (MLK-Day)**		
3	1/17/24	2	Wed.	2	Physical Properties of Pure Compounds		
4	1/19/24	2	Fri.	2	Physical Properties of Pure Compounds	1	
5	1/22/24	3	Mon.	2	Physical Properties of Pure Compounds	**Pre-lab**	
6	1/24/24	3	Wed.	**2**	**Computational Lab: Thermodynamic Models**		**Pre-lab**
7	1/26/24	3	Fri.	3	Material and Energy Balances	2	1
8	1/29/24	4	Mon.	3	Material and Energy Balances		
9	1/31/24	4	Wed.	3	Material and Energy Balances		
10	2/2/24	4	Fri.	4	Entropy	3	2

11	2/5/24	5	Mon.	4	Entropy		
12	2/7/24	5	Wed.	4	Entropy		
	2/9/24	5	Fri.		**Quiz 1**	4	3
13	2/12/24	6	Mon.	5	Thermodynamic Processes and Cycles		
14	2/14/24	6	Wed.	5	Thermodynamic Processes and Cycles		
15	2/16/24	6	Fri.	5	Thermodynamic Processes and Cycles	5	4
16	2/19/24	7	Mon.	5	Thermodynamic Processes and Cycles		
17	2/21/24	7	Wed.	5/6	Thermodynamic Models of Real Pure Compounds		
18	2/23/24	7	Fri.	6	Thermodynamic Models of Real Pure Compounds	6	5
	2/26/24	8	Mon.		**No Class (Spring Break)**		
	2/28/24	8	Wed.		**No Class (Spring Break)**		
	3/1/24	8	Fri.		**No Class (Spring Break)**		
19	3/4/24	9	Mon.	6	Thermodynamic Models of Real Pure Compounds		
20	3/6/24	9	Wed.	6	Thermodynamic Models of Real Pure Compounds		
	3/8/24	9	Fri.		**Quiz 2**	7	6
21	3/11/24	10	Mon.	6	Equations of State		
22	3/13/24	10	Wed.	7	Equations of State		
23	3/15/24	10	Fri.	7	Equations of State	8	7
24	3/18/24	11	Mon.	7	Equations of State		
25	3/20/24	11	Wed.	7	Modeling Phase Equilibrium for pure Compounds		
26	3/22/24	11	Fri.	8	Modeling Phase Equilibrium for pure Compounds	9	8
27	3/25/24	12	Mon.	8	Modeling Phase Equilibrium for pure Compounds		
28	3/27/24	12	Wed.	8	An Introduction to Mixtures		
	3/29/24	12	Fri.		**Quiz 3**	10	9
29	4/1/24	13	Mon.	9	An Introduction to Mixtures		
30	4/3/24	13	Wed.	9	An Introduction to Mixtures		
31	4/5/24	13	Fri.	10	Vapor-Liquid Equilibrium	11	10
32	4/8/24	14	Mon.		**No Class (Eclipse)**		
33	4/10/24	14	Wed.	10	Vapor-Liquid Equilibrium		
34	4/12/24	14	Fri.	10	Vapor-Liquid Equilibrium	12	11
35	4/15/24	15	Mon.	10	Vapor-Liquid Equilibrium		
36	4/17/24	15	Wed.	10/11	Vapor–Liquid Equilibrium of Mixtures		
37	4/19/24	15	Fri.	11	Vapor–Liquid Equilibrium of Mixtures		12
38	4/22/24	16	Mon.	11	Vapor–Liquid Equilibrium of Mixtures		
	4/25/24		**Thurs.**		**Final Exam (4:00-6:00 pm)**		

Quizzes:

Quizzes Date, Time, and Instructions Quizzes will be 50 minutes during the lecture time to avoid potential scheduling conflicts. Quiz locations will be announced in class or via Canvas announcement. Special circumstances will be discussed and accommodated individually – if you believe you will need to miss a quiz, contact Prof. Lindsey ASAP!

Homework:

Weekly homework problems (2-3 questions) will be posted on Canvas on Fridays at noon, and due the following Friday by 11:59 pm. Canvas can be accessed by searching for "Canvas" on the Wolverine Access website.

Submit assignments using Gradescope: Entry Code: 5J4D25

Problems should be completed individually (limited collaboration): attempt every problem on your own before discussing with classmates. All calculations and write-up must be completed on your own, from scratch Copying full- or partial-solutions from previous year's materials is will be treated as plagiarism.

Be sure to show your work. If you're wondering "is it necessary to show this step," assume the answer is yes. Points will be deducted if work is not shown. Moreover, likelihood of receiving partial credit decreases with decreasing work shown.

Late Assignments: Late work can still be submitted within 48 hour period after the due date, i.e. by Sunday midnight, but will be deducted 40%. If foreseen or unforeseen circumstances prevent you from completing an assignment on time, you may request an extension. Extensions must be requested in advance of the due date.

Grading:

Your final grade will be calculated based on your homework (35%), quizzes (30%), final exam (32.5%) and participation (2.5%). Your two lowest HW scores will be dropped and the final course grade will be curved. Minimum cutoffs for each grade are given below – curving will never make this scale stricter (e.g., the A–/B+ cutoff will never be *higher* than 85%, but may be lowered. Note that grade assignment is instructor and semester-specific, hence historical information should not be treated as future guarantee.

- A–/B+ cutoff: 85%
- B–/C+ cutoff: 70%
- C–/D+ cutoff: 55%

Re-grading Requests: You may request homework assignment, quiz, or exam grading be reevaluated. All such requests must be emailed to and approved by our GSIs before they are submitted through Gradescope.

Submit the assignment, project, quiz, or exam in question and a note that explains your concerns about the grading. Re-grading requests must be made within one week from the date that an assignment or exam is returned. No requests for re-grades will be granted after the one-week grace period has expired. There is also a one-week limit for notifying your instructor in the event that an assignment has not been returned to you. Note that regrading can also result in point deduction if improperly awarded points are found as well!

Plagiarism: Presenting someone else's ideas as your own, either verbatim or recast in your own words – is an academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in our campus policies.

- https://ecas.engin.umich.edu/honor-council/
- https://guides.lib.umich.edu/academicintegrity

Class Participation:

Students get full credit (2.5) if you are in the top 2/3 of the class in either views, posts, or answers in Piazza (i.e. asking questions, answering questions, or checking the question/answer will count). Students who show some participation will get partial credit (1), and no credit (0) if don't view or post anything.
Bonus credit (1): (top 5 post, top 5 viewer, top 5 answer). Do not accumulate (i.e. maximum bonus credit per student is 1)

Learning Resources:

There are a multitude of opportunities for learning beyond course lectures and office hours. These opportunities include:

Recitations: These are mandatory for all enrolled students. Sessions are held by course GSI's and will include a deeper dive into course material, example problems, and software demonstration (e.g., using Microsoft Excel).

Sunday Reviews: These are optional but highly encouraged. Sessions are held by IAs and will provide further review. Note: Your IAs are among the top students to have taken this course in their year – they can offer valuable insights and tips for success! This year, Sunday Reviews will be held on Central Campus in CHEM 1300, from 3:00-4:30p.

Tutoring: The course has a tutor that can be reserved for 1:1 sessions if you need additional help. Reach out to them directly to schedule.

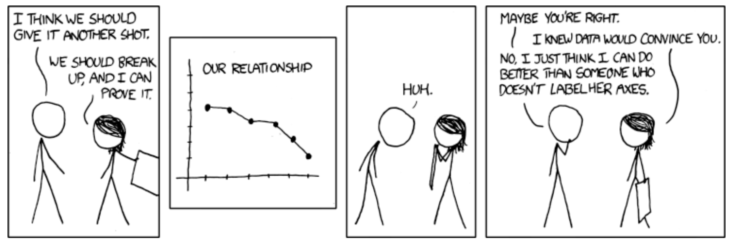
Online resources: Check out https://learncheme.com for supplementary learning opportunities. This is an excellent website that I even pull from to develop course demos!

Tips for success:

This is not an easy course. You will be introduced to abstract concepts and learn how to creatively apply them to solve complex problems that builds **directly** upon content you learned in your CHE 230 course. This takes time and practice to learn how to do well. So how can you position yourself for success?

1. Don't "ease in" to the semester. Chapter 1 through 3 might feel like a review of concepts you've learned in your prior physics, chemistry, and CHE 230 classes, which might make it tempting to take it easy on homework and quiz 1. Don't! It will only get harder from here, so this first portion of the class is your best opportunity to lock in some high homework/quiz points. Moreover, the rest of the course will build upon these concepts, so it's critical that you feel comfortable with them.

2. Always state your assumptions, show your work, and label your axes. You're here to learn to become engineers. In the professional world, one our most critical responsibilities is clearly communicating our findings *and how we arrived at them*. Would you be willing to move next door to a chemical plant for which the engineers provided no proof of design? How about one for which no one else checked over the work? Or maybe a plant design that is missing labels? Beyond the engineering ethics, showing your work also helps us give you better feedback when you have questions, and, as mentioned in the grading section, increases the likelihood of receiving full/partial credit.



3. Study together and take advantage of office hours/tutoring/Sunday review. You'll find that both in the classroom and in your future careers as engineers, the best way to solve complex problems is by working in teams. The primary reason this strategy is so effective is that everyone brings a unique viewpoint and understanding of the task at hand. Perhaps the homework relies on a concept I discussed in class that doesn't quite "click" for you. So listen to your GSIs, IAs, tutors, and fellow students discuss the same concept from there unique perspective – one them might just click for you! This leads into my next point, which is:

4. Use this class as an opportunity to learn new skills. I'm a huge fan of the quote "If you're not cheating, you're not trying hard enough." This does *not* mean I condone cheating in class. However, I encourage you to find ways to make your life easier. Have a complicated equation of state (EOS) you need to calculate? Consider using the homework assignment as a chance to learn/practice your python skills and make a little EOS calculator. Find yourself doing a lot of plotting? Why not practice using Matplotlib? Recently take a C++ class? Challenge yourself to write a compiled version of the code too!

5. Take advantage of the fact you live in the information age. Resources like https://learncheme.com provide mini lectures from other renowned faculty working in Chemical Engineering education. There are innumerable thermodynamics books available online. Take some time to check out these resources and find which one resonates best with you. But…

6. Be wary of large language models like ChatGPT. I know no matter what I say you are going to use these resources, but it's important to understand when and how to use them – see my longer blurb below.

7. Practice Practice Practice. Students often think that if they can successfully solve problems from class, homework, and past quizzes, that they'll be successful on, e.g., quizzes and final exams, but this is not necessarily the case. A key goal of this course is to teach you creative problem solving. This means the ability to apply concepts from class to completely different problems – not just perturbations of what you've already seen. So how can you prepare yourself for this? Work through problems at the end of each chapter with your study group or problems on https://learncheme.com. The more problems you see, the more "flexible" your brain will become when tackling new problems.

8. Take advantage of Piazza. This is a wonderful resource that I wish existed when I was a student. See more in the "Classroom Technology" section below.

9. Breathe. Stress management is a critical skill to learn while you're in college. Figure out your signs of burn out and what works to get you into a better headspace. If you're feeling frustrated and want some engineering inspiration, consider watching my all-time favorite movie, Hidden Figures.

10. Know there's help if you need it. If you're feeling overwhelmed and think you need help, don't hesitate to reach out to the university C.A.R.E. Center (https://care.engin.umich.edu)

A Note on Large Language Models (LLMs) (e.g. ChatGPT):

I recognize that students now fundamentally integrate LLMs into their academic and research workflows. However, I ask that you think critically about how and when you decide to use these tools for this course.

You'll be learning advanced physics- and engineering-based concepts during this course - these are areas where LLMs tend to struggle. LLM's don't tell you when they're making things up. They are also quite impressionable (you can convince them that factually correct information is wrong. This is problematic for student users - if you're just learning these concepts, it can be exceedingly difficult to tell when LLMs are making things up, and hard to "fact check" them. You don't know what you don't know!

However, that doesn't mean you need to completely avoid these tools! In the "Tips for Success" section, I mentioned taking this course as an opportunity to, e.g., hone your Python coding/plotting skills. This is an excellent use-case for ChatGPT, which is known to excel at code generation and debugging. It's also quite easy to "fact-check" this type of ChatGPT output, since you can always verify the results by hand.

Irrespective of how you choose to use this tool, be sure to describe (1) how you used it, (2) the benefits/challenges you encountered, (3) how you fact-check it on each assignment.

Students with Disabilities and/or in Need of Special Accommodations:

Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with Office of Students with disabilities, G-664 Haven Hall, 734 763 3000, http://ssd.umich.edu/, to verify their eligibility for appropriate accommodations.

If you are a pregnant, parenting student, or primarily responsible for providing care for a loved one or family member, and you are in need of any accommodations, please let Prof. Lindsey know at your earliest convenience. You may also reach out to https://www.mcasp.org and CEW+ (https://www.cew.umich.edu) for resources and community support.

Reaction Engineering and Design
ChE 344 – Winter 2024
Department of Chemical Engineering
University of Michigan

INSTRUCTOR: Eranda Nikolla

TEXT: **Elements of Chemical Reaction Engineering** by H. Scott Fogler (6th edition). Prentice Hall.
Textbook Website: http://www.umich.edu/~elements/6e/
The textbook website will have links to Wolfram problems.

LECTURES: Tuesday, Thursday 9:30 – 11:20 am in 1013 Dow

- **9:30 am – 10:50 am will be lecture.** Lecture Outlines will be posted before class (one day before) and Lecture Notes (filled out) will be posted to Canvas after the Lecture. Lecture Recordings will be recorded and available on Canvas.
- **10:50 am – 11:20 am will be group "In-class problems (ICPs)",** which are substituting recitations. Discussion/recitation will take place in the form of in-class-problems (ICPs) to be completed in person during the final 30 minutes of the lecture period. ICPs are discussed in more detail below and contribute to 15% of your total grade.
- Optional Sunday review will be held each week, beginning mid-January 2023.

COURSE WEB PAGE: See Canvas

COURSE OBJECTIVES:

In this course you will learn how to analyze chemical reactors and reaction systems, develop critical and creative thinking skills, solve open-ended problems, and practice solving reaction engineering problems using computer software.

PREREQUISITES:

ChE 330, ChE 342

COURSE OUTCOMES:

- Describe the process to solve chemical reaction engineering problems (reactor design)
- Size isothermal, adiabatic, and nonadiabatic reactors for homogeneous and heterogeneous reactions
- Analyze multiple reactions carried out both isothermally and non-isothermally in flow, batch, and semi-batch reactors to determine selectivity and yield
- Determine the reaction order and rate constant from experimental data
- Use ordinary differential equation solvers to size and analyze reactors with multiple reactions and heat effects

GRADING:

In class problems	15% (lowest 6 ICP scores will be dropped)
Participation (e.g., office hours, participation in ICPs/class)	5%
Homework	15% (lowest 1 HW will be dropped)
Midterm Exam 1	20%
Midterm Exam 2	20%
Final Exam	25%
Total	**100%**

A-/B+ cutoff is 90%, B-/C+ cutoff is 80% C-/D+ cutoff is 70%
Grade cutoffs will be adjusted at the end of the semester based on Prof. Nikolla's discretion.

CANVAS:
The Canvas site will serve for posting information for the class, including:

- Lecture slide outlines will be posted before each class
- Announcements and class polls
- Homework problem statements
- Grades
- Solutions to homework, and in-class problems (ICPs)
- Annotated lecture slides

Lecture recordings will be recorded through the CAEN lecture capture system and can be accessed through the Canvas site.

TEACHING PERSONNEL:

Name	**Role**	**Office**	**Email (@umich.edu)**
Eranda Nikolla	Instructor	NCRC B28, 2004E	erandan
Dylan Marx	Graduate Student Instructor		marxd
Chris (Do-Hoon) Kim	Graduate Student Instructor		umdkim
Ben Spector	Instructional Aide		spectorb
Nicolette Kleinhoffer	Instructional Aide		nmkleinh
Isabelle Montilla	Proctor		inmo
Nadine El Ghaffir	Tutor		nghaffir

OFFICE HOURS: Locations will be updated shortly

Monday	Nicolette Kleinhoffer	1:30-2:30 pm	DOW 3216
Monday	Do Hoon (Chris) Kim	5-6pm	DOW 3216
Tuesday	Dylan Marx	2-3pm	DOW 3216
Tuesday	Prof. Nikolla	3-5pm	DOW 3216
Wednesday	Ben Spector	1:30-3:30 PM	DOW 3216
Wednesday	Do Hoon (Chris) Kim	5-6pm	DOW 3216
Thursday	Dylan Marx	2-3pm	DOW 3216
Thursday	Nicolette Kleinhoffer	12:30-1:30pm	DOW 3216
Friday	Nadine Ghaffir	10:30-12:30pm	DOW 3216
Friday	Isabelle Montilla	1:30-3:30pm	DOW 3216
Sunday Review	Nicolette Kleinhoffer/Ben Spector	11am - 12:30 PM	Central Campus Angell Hall Aud C

IN-CLASS PROBLEMS (ICPs):
Students will work in assigned groups of 3 or 4 to complete in-class problems. **These problems will be graded, and all participating members of the group will receive the same score.** All students are expected to actively participate in the ICPs. Names that appear on the ICP submitted should only be those who actively participated in the submission. **Thus, if you were there and did actively contribute, make sure your name is listed before submission, or you will not receive credit. Evaluation of the team members will be conducted each time before the team changes during the semester.** This will count toward the participation grade.
No late ICPs will be accepted. The lowest six ICP scores will be dropped.

Please note that 80% of the points are received even for attempting the ICP.

PARTICIPATION:
There are several ways to get participation points for the course. A main way is through active interaction in the in-class problems (ICPs). You are also encouraged to participate during lecture, and regularly attend office hours and Sunday reviews. You do not need to be the most active participant to get full points (i.e., I hope that many people will participate actively, and all get full participation points).

PIAZZA:
We will be using Piazza for class discussion. Piazza is connected to Canvas (you can see Piazza on the Canvas menu bar). The system is designed to help you receive efficient help from your classmates, the GSIs, the IAs, tutors, and myself. Questions pertaining only to the individual can be sent via email (e.g., illness), but all questions about course material, exams, etc. should be submitted via Piazza to ensure that this information is available to all students in the course. Keep in mind that although Piazza is anonymous between your classmates, they are not anonymous to the instructors.

Signup Link:
https://piazza.com/demo_login?nid=lr0onwxrjc01o2&auth=1710833

HOMEWORK:
Homework will be posted at least one week before the due date on Canvas. Homework assignments must be submitted **before 5:00 pm on GradeScope (see Canvas) on the day they are due.** Homework should be written on 8.5 x 11 inch paper with straight edges. In the upper right-hand corner of the first page, **please write the homework number, due date, and your name**. Solutions should be written neatly, and solutions should be boxed. Each homework will have a cover sheet that must be filled out and will give specific guidelines for the assignment. Graders may subtract points for homework that does not follow these guidelines. Late homework, submitted within 24 hours of the due date, will receive a 30% grade reduction. No credit will be awarded after that point. Your lowest homework assignment grade of the semester will be dropped.

You are not allowed to possess, look at, use, or in any way derive advantage from work not done by you, including solutions from former students, textbook solution manual or solutions made available by instructors in previous years, **except those available on the textbook website, which are available to everyone**. You must work the assignment alone. You may, however, discuss general strategies for solving homework problems with others. You must complete and document all calculations, from scratch to final form, on your own. Copying of another student's work is forbidden, as is allowing another student to copy your work.

EXAMS:
There will be two midterm exams and one final exam. **All exams will be closed textbook and closed internet. Each student can bring with them a 1-page formula only sheet (8.5 x 11 in).** For Midterm 2 you may use your Midterm 1 sheet as well, and for the Final you may use your Midterm 1 and 2 sheets. Writing on the front and back is allowed. Students must turn in their formula sheet with their exam.

No additional materials (class notes, old exams, old quizzes, homework sets, internet, and other worked out problems) will be allowed during the exams. Any deviation will be considered an honor code violation and dealt with accordingly. All exams will be administered under the College of Engineering Honor Code. You must sign the pledge: "I have neither given nor received aid on this examination, nor have I concealed any violations of the honor code" after taking each exam. Failure to do so gives the instructor the right to refuse to grade that exam or quiz. Suspected violations of the honor code should be brought to the attention of your instructor, or directly to the Honor Council.

For Exam Times, if you are unable to take the exam at the specified time, please let me know at least two weeks beforehand so that we can make accommodations.

Midterm 1: 9:30 to 11:30 am February 22, 2024 (2 hours): Additional exam rooms TBD.

Midterm 2: 9:30 to 11:30 am April 4, 2024 (2 hours): Additional exam rooms TBD.

Final Exam: Assigned time from the University is **Tuesday, April 30 8:00-10:00am**.
You may use your Midterm 1 sheet, your Midterm 2 sheet, and **two** new sheets specifically for the Final. You should also have a writing utensil and a calculator. Additional exam rooms TBD.

ChE 344 TENTATIVE COURSE SCHEDULE: Subject to change

#	Date	Topic	Chapter	ICP#	Posted	Due*
1	1/11/2024	Introduction and ideal reactors	1	n/a		
2	1/16/2024	Male balance and Conversion	2	1		
3	1/18/2024	Reactor Staging and Rate Law	3	2	HW 1	
4	1/23/2024	Stoichiometry: Batch and Flow	4.1-2	3		
5	1/25/2024	Stoichiometry: Reversible Reactions	4.3	4	HW2	HW1 (1/26 at midnight)
6	1/30/2024	Isothermal Reactor Design	5.1-5.4	5		
7	2/1/2024	Isothermal Reactor Design ((cont.)	5.1-5.4	6	HW3	HW2 (2/2 at midnight)
8	2/6/2024	Isothermal Reactors with Pressure Drop	5.5	7		
9	2/8/2024	Semi-batch Reactor Conversion and Sizing	6	8	HW4	HW3 (2/9 at midnight)
10	2/13/2024	Membrane Reactor Conversion and Sizing	6	9		
11	2/15/2024	Collection and Analysis of Rate Data	7	10	HW5 Practice problems for Midterm 1; (not to turn in)	HW4 (2/16 at midnight)
12	2/20/2024	Collection and Analysis of Rate Data ((cont.)	7	11		
	2/22/2024	**Midterm 1 9:30-11:30 am**		n/a		
	2/27/2024	*No class, winter vacation*				
	2/29/2024	*No class, winter vacation*				
13	3/5/2024	Multiple Reactions	8	12		
14	3/7/2024	Multiple Reactions (cont.)	8	13	HW6	
15	3/12/2024	Intro to Non-isothermal Reactor Design, Adiabatic Reactor	11.1-11.4	14		
16	3/14/2024	Intro to Non-isothermal Reactor Design, Reversible reactions (cont.)	11.4-11.5	15	HW7	HW6 (3/15 at midnight)
17	3/19/2024	Interstage Heating/Cooling, Intro to Heat Exchange	11.6, 12.1	16		

18	3/21/2024	Steady-state, Non-isothermal Reactor Design with Heat Exchange	12.2-12.4	17	HW8	HW7 (3/22 at midnight)
19	3/26/2024	CSTR w/ Heat Exchange: Multiple Steady States and Multiple Reactions	12.5-12.6	18		
20	3/28/2024	Safety and Reaction Engineering	13	19	HW9 Practice problems for Midterm 2; (not to turn in)	HW8 (3/29 at midnight)
21	4/2/2024	Reaction Mechanisms, PSSH	9.1	20		
	4/4/2024	**Midterm 2 9:30-11:30 am**		n/a		
22	4/9/2024	PSSH cont., Enzyme Kinetics	9.2-9.3	21		
23	4/11/2024	Quasi-equilibrium, Rate Determining Step	10	22	HW10	
24	4/16/2024	Heterogeneous Catalysts, Langmuir Kinetics	10	23		
25	4/18/2024	Catalysis: External & Internal Mass Transfer	14, 15	24	HW11 Practice problems for final; (not to turn in)	HW10 (4/19 at midnight)
26	4/23/2024	Catalysis: External & Internal Mass Transfer (cont.)	14, 15	n/a		
	4/30/2024	**Final Exam: 8:00am-10:00am**	Cumulative			

***Homework will be due the next day (Friday) at midnight.**

HONOR CODE:
This course will operate under the College of Engineering Honor Code. (See https://ecas.engin.umich.edu/honor-council/policies-interpretations/ for an explanation of the honor code). All exams are to be done independently and individually (absolutely no collaboration is permissible). Discussion about concepts in the class pertaining to homework is permitted. Work submitted must be your own, however. It is not acceptable for one person to solve a problem and then allow others to copy that solution. Suspected violations of the Honor Code will be submitted to the Honor Council for resolution.

REGRADE REQUESTS:
Late requests will not be honored.

- **For Homework and ICPs:**
  For homework regrade requests, resubmit through GradeScope. For ICP regrade requests, also resubmit through GradeScope. Regrades for ICPs and homework must be submitted within one week after the assignment is returned/grades posted.

- **For Midterms:**
  Submit a regrade request via an email "ChE 344 Midterm [1 or 2] Regrade Request-[your name]" to **Professor Nikolla (erandan@umich.edu), and attach a pdf document outlining your regrade request no later than 48 hours after the Midterms**. For simple corrections to summing up points we will just check the math, but if you request a regrade for a Problem, the entire Problem will be regraded, and the new grade will be given. This can cause the Problem score to either increase or decrease.

- **For Final Exam:**
  Submit a regrade via an email "ChE 344 Final Exam Regrade Request-[your name]" to **Professor Nikolla (erandan@umich.edu), and attach a pdf document outlining your regrade request no later than 24 hours after receiving a grade, to allow sufficient time to post grades**.

ACCESSING LIVING EXAMPLE PROBLEMS (LEPS):
You may access the LEPs at http://www.umich.edu/~elements/5e/live/index.html. You will need to download the corresponding software package (e.g., Wolfram CDF Player) to run the programs. On CAEN computers, the LEPs must be run using Polymath or Matlab, as CDF cannot be run on CAEN. On personal computers all the programs can be run after downloading the software.

ACCESSING INTERACTIVE COMPUTER GAMES:
You may access the Interactive Computer Games through a personal computer or a CAEN Computer:
To access it using a personal computer:
Go to the textbook website http://www.umich.edu/~elements/5e/icm/index.html, and download the corresponding ICG.

To access it using a CAEN computer (instructions also included in the link above):
Step 1: On a CAEN network computer (not connected via VPN), search "ICM" on AppsAnywhere
Step 2: Open ChE 344 ICM, this will open "tic tac toe"
Step 3: Once "Tic tac toe" is open, navigate to Windows start menu (Windows icon in bottom left)
Step 4: In the index, under ChE 344 ICM, the rest of the modules will appear and you can open whichever one you choose (Murder Mystery for HW 3, problem 6).
Note: finding the other modules in the start menu is only possible once the app is loaded in step 2.

POLYMATH TUTORIALS:
There are Polymath Tutorials for linear equations, nonlinear equations, ODEs, regression, etc., available on the textbook website at:
http://www.umich.edu/~elements/5e/software/polymath.html. There is also a tutorial on Canvas as well as an example video posted in the Media Gallery.

ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES:
If you think you need an accommodation for a disability, please let me know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way the course is usually taught may be modified to facilitate your participation and progress. As soon as

you make me aware of your needs, we can work with the Office of Services for Students with Disabilities (SSD) to help us determine appropriate academic accommodations. SSD (734-763-3000; https://ssd.umich.edu/) typically recommends accommodations through a Verified Individualized Services and Accommodations form. Any information you provide is private and confidential and will be treated as such.

DIVERSITY STATEMENT: I consider this classroom to be a place where you will be treated with respect, and I welcome individuals regardless of race, color, national origin, age, marital status, sex, sexual orientation, gender identity, gender expression, disability, religion, height, weight, or veteran's status – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.

HEAT TRANSFER
ME 335-001, Fall 2023 (08/28/2023 - 12/06/2023)

Lecture
Class meets in-person **Tu/Th 9:00-10:30 am (1500 EECS)**. Lectures will be posted on Canvas at https://umich.instructure.com/courses/633815/external_tools/1262

Course website
https://umich.instructure.com/courses/633815

Instructor
Solomon Adera (he/him/his)
Email: sadera@umich.edu
Ph. (617) 852-2962
Office hour: Tu/Th 10:30-11:30 am in 2428 GG Brown. Additional office hours are available upon request.

Graduate Student Instructor (GSI)
Yimin Zhou (she/her/hers)
Email: yiminzh@umich.edu
Office hour: Tu 5-7p (Findley A), Wed 4-7p (Findley D), Th 5:30-8:30p (Findley F)

Prerequisites
Math 215, ME 235, ME 240, and ME 320 (C or better).

Textbook

Fundamentals of heat and mass transfer by Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. Dewitt, 8th edition, 2019 (ISBN: 978-1-119-35388-1)

Additional textbooks

A heat transfer textbook by John H. Lienhard IV and John H. Lienhard V, 5th edition, 2020 (free download at https://ahtt.mit.edu/)
Conduction heat transfer by V. S. Arpaci, Abridged Edition, 1991 (Ginn Press, Nedham)
Convective heat transfer by A. Bejan, 3rd edition, 2013 (John Wiley & Sons, Inc.)
Radiation heat transfer notes by D. K. Edwards, 1981 (Hemisphere: Washington)

PSETS
A total of twelve problem sets (PSETS) will be assigned one week before they are due. Due dates are indicated on the syllabus. PSETS should be uploaded on Canvas before midnight (11:59 pm) on the due date. Each PSET contains 5 questions and the solution key will be posted on Canvas after all submissions are collected. Two of the lowest PSET grades will be dropped, only 10 PSETS will count towards your final grade.

You are encouraged to work with friends on PSETS, but the final solutions should be yours. Late submissions will be penalized by 10% per day past the due date unless permission is obtained from the instructor 24 h prior to the due date. If you encounter problem uploading your solution, notify the instructor by email immediately to avoid penalty for late submission.

Unfair advantage
You may not possess, look at, use, or in any way derive advantage from prior year PSETS and EXAMS.

Potential changes to syllabus
As they have throughout the past two years, policies around academic and public health are subject to change. This course will follow all policies issued by the university, which are documented on the campus blueprint's FAQ. These policies may change over the course of the term, so please review the campus

blueprint's FAQ for the most up to date information. Major changes to syllabus will be communicated during lecture and/or posted on the course website.

Course outcomes & assessment
It is expected that the students will gain a fundamental physical and mathematical understanding of heat transfer rather than memorizing equations. By this, it is implied that the student will be able to correctly apply the course content to new situations so as to evaluate potential industrial applications of heat transfer through physical induction and mathematical analysis. Such inductive and analytical reasoning will be taught through examples and assignments.

Students' understanding and mastery of the concepts will be assessed through **12 PSETS and 3 EXAMS**. All EXAMS will be held at the time and date indicated on the syllabus. Please keep these times free of other engagements. If you have conflict with those dates, bring this to the instructor's attention within the first two weeks of the start of the semester. All EXAMS will be comprehensive and cover material up to the date of the EXAM with emphasis on the newer material. Collaboration on EXAMS is not allowed and you will be asked to sign the honor code.

Grading
PSETS 20%
MIDTERM EXAMS 2×20%
FINAL EXAM 40%

Regrading policy
Regrading requests should be addressed to the GSI. All regrading requests should be submitted within one week after the work is returned. All regrading requests (PSETS and EXAMS) should be in writing (not emails) with the original work attached.

Makeup exam policy
If you miss an EXAM, you need to provide sufficient evidence (within one week) to request a makeup EXAM.

Attendance and class participation
Attendance and class participation is highly encouraged but not required. If you miss a lecture, you are encouraged to watch the recorded lecture. You can also reach out to your classmates for help and/or come to office hours to discuss with the instructor or the GSI.

Course description
This course provides fundamental knowledge on introductory heat transfer. The topics covered in this courser include: (a) Modes of heat transfer; (b) Thermal circuit, (c) Conduction (steady-state and transient analysis); (d) Convection (forced and natural convection); (e) Thermal boundary layer analysis; (f) Heat exchanger design and analysis, (g) Phase change (boiling and condensation); (h) Scaling analysis; (i) Thermal radiation (radiation exchange between surfaces).

Learning objectives
The topics covered in this course include conservation laws, inviscid and viscous flows, and dimensional analysis. After successfully completing this course, students are expected to understand the following concepts.

- Fundamental concepts in heat transfer
- Steady state and transient heat transfer
- Modes of heat transfer (conduction, convection, and radiation) and the respective rate equations
- Thermodynamics first and second laws

- Thermal properties of matter including thermal conductivity
- Heat diffusion equation
- Boundary and initial conditions
- 1D steady state heat conduction in Cartesian and radial systems
- Thermal resistance and thermal circuit modeling
- 1D steady state heat conduction in extended surfaces
- Transient conduction and lumped capacitance method
- Velocity and thermal boundary layers
- Boundary layer equations and similarity and Reynolds analogy
- Thermal analysis for fully developed laminar flow in tubes
- Heat transfer correlations for forced internal and external convection
- Heat transfer correlations for free and forced convection
- Heat exchanger design and analysis
- Radiation intensity and blackbody radiation
- Emission, absorption, reflection, and transmission by real surfaces
- View factor and radiation exchange between surfaces
- Phase change heat transfer (boiling and condensation)

Diversity, equity, and inclusion (DEI)
I consider this classroom to be a place where you will be treated with respect. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. I am dedicated to helping each of you achieve all that you can in this class. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class. Your suggestions are encouraged and appreciated. I may, either in lecture or smaller interactions, accidentally use language that creates offense or discomfort. Should this happen, please contact me and help me understand and avoid making the same mistake again.

Lived name/pronoun
I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records.

Student mental health
As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The University of Michigan is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. You can learn more about the broad range of confidential mental health services available on campus via
http://crlt.umich.edu/blog/new-crlt-resource-supporting-students-facing-mental-health-challenges

Student well-being
Students may experience stressors that can impact both their academic experience and their personal well-being. These may include academic pressure and challenges associated with relationships, mental health, alcohol or other drugs, identities, finances, etc.

If you are experiencing concerns, seeking help is a courageous thing to do for yourself and those who care about you. If the source of your stressors is academic, please contact me so that we can find solutions together. For personal concerns, U-M offers the following resources:

(1) Counseling and Psychological Services (CAPS) - confidential; 734-764-8312; for after-hours urgent support, call and press 0; counseling, workshops, groups and more, counselors are embedded in some schools
(2) Dean of students office - 734-764-7420; provides support services to students and manages critical incidents impacting students and the campus community
(3) Ginsberg center for community service learning - 734-763-3548; opportunities to engage as learners and leaders to create a better community and world
(4) Multi-Ethnic Student Affairs (MESA) - 734-763-9044; diversity and social justice through the lens of race and ethnicity
(5) Office of student conflict resolution - 734-936-6308; offers multiple pathways for resolving conflict
(6) Office of the Ombuds - 734-763-3545; students can raise questions and concerns about the functioning of the university
(7) Services for Students with Disabilities (SSD) - 734-763-3000; accommodations and access to students with disabilities
(8) Sexual Assault Prevention and Awareness Center (SAPAC) - confidential; 734-764-7771 or 24-hour crisis line 734-936-3333; addresses sexual assault, intimate partner violence, sexual harassment, and stalking
(9) Spectrum center - 734-763-4186; support services for LGBTQ+ students
(10) Trotter multicultural center - 734-763-3670; intercultural engagement and inclusive leadership education initiatives
(11) University Health Service (UHS) - 734-764-8320; clinical services include nurse advice by phone, day or night
(12) Well-being for U-M student - searchable list of many more campus resources
(13) Wolverine wellness - confidential; 734-763-1320; provides wellness coaching and much more

Title IX statement
Title ix makes it clear that violence and harassment based on sex and gender is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, etc. If you or someone you know has been harassed or assaulted, you can find the appropriate resources here:

- UM Sexual Assault and Prevention Center (SAPAC) 24-hour confidential crisis line
  (734) 936-3333 * http://sapac.umich.edu/
- UM Counseling and Psychological Services (CAPS)
  (734) 764-8312 * http://caps.umich.edu/
- University of Michigan Police (DPSS)
  (734) 763-1131 (or 911 for emergency) * http://www.dpss.umich.edu/
- UM Office of Student Conflict Resolution
  (724) 936-6308 * http://oscr.umich.edu
- UM Newnan Academic Advising Center
  (734) 764-0332 * https://lsa.umich.edu/advising

Honor code
All students in the class are presumed to be decent and honorable, and all students in the class are bound by reasonable standards of conduct and the University of Michigan College of Engineering honor code. You may not seek to gain an unfair advantage over your fellow students; you may not consult, look at, or possess the unpublished work of another without their permission; and you must appropriately acknowledge your use of another's work. Any violation of the honor policies appropriate to each piece of course work will be reported to the honor council, and if guilt is established penalties may be imposed by the honor council and faculty committee on discipline. Such penalties can include, but are not limited to, letter grade deductions or expulsion from the university. If you have any questions about this course policy, please consult with the instructor.

In this class, as in many others at the university, you will be expected to include and sign the honor pledge on each assessment you submit. The honor pledge reads as follows:
I have neither given nor received unauthorized aid on this assignment, nor have I concealed any violations of the honor code.

The honor code is based on these tenets:
(a) Engineers must possess personal integrity both as students and as professionals. They must be honorable people to ensure safety, health, fairness, and the proper use of available resources in their undertakings.
(b) Students in the college of engineering community are honorable and trustworthy persons.
(c) The students, faculty members, and administrators of the college of engineering trust each other to uphold the principles of the honor code. They are jointly responsible for precautions against violations of its policies.
(d) It is dishonorable for students to receive credit for work that is not the result of their own efforts.

Among other things, the honor code forbids plagiarism. To plagiarize is to use another person's ideas, writings, etc. as one's own, without crediting the other person. Thus, you must credit information obtained from other sources, including web sites, emails or other written communications, conversations, articles, books, and other sources of information.

On team assignments, the co-authors listed on the submission should include only those team members who have contributed their fair share to the assignment. If you allow a teammate's name to appear on an assignment to which he/she has not contributed fairly, then you are violating the honor code.

Accessibility and accommodations
If you have any disability as defined under the Americans with Disabilities Act that might interfere with your ability to participate in class, or to turn in assignments on time or in the form required, please contact your instructor and the Office of Students with Disabilities at the start of the term so that arrangements can be made to accommodate you. The University of Michigan and the Mechanical Engineering Department are committed to providing equal opportunity for participation in all programs, services, and activities. Requests for accommodations by persons with disabilities may be made by contacting the services for Students with Disabilities (SSD) office located at G-664 Haven Hall.

If you think you need an accommodation for a disability, please let me know at your earliest convenience, preferably at the beginning of the term, or at least two weeks prior to the need of accommodation (exam, projects, etc.) Some aspects of this course, the assignments, the in-class activities, and the way the course is usually taught may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, we can work with the Services for Students with Disabilities (SSD) office to help us determine appropriate academic accommodations. SSD (734-763-3000; http://ssd/umich.edu) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. Any information you provide is private and confidential and will be treated as such.

Religious/cultural observance
Persons who have religious or cultural observances that coincide with this class should let the instructor know by email within the first two weeks after the semester started. I strongly encourage you to honor your cultural and religious holidays. However, if I do not hear from you within two weeks since the start of the semester, I will assume that you plan to attend all classes.

Course add/drop policy
Course add/drop is through Wolverine Access. Before dropping the course, you are encouraged to consult with the instructor. For specific deadlines regarding add/drop, refer to
https://bulletin.engin.umich.edu/academic-calendar-and-deadlines/undergraduate-deadlines/

Important dates
Fall Full term classes begin-Monday, August 28
Fall Full Term classes last day to audit/drop without "W" on official transcript and without need for Late/Drop/Add/Swap/Edit-Monday, September 18
Fall Full term classes drop and pass/fail deadline without SSC Petition-Wednesday, December 6
Fall Full term classes end-Wednesday, December 6

ME 335 - Heat Transfer
Fall 2023 Tentative Lecture Schedule

Wk	**Date**			**Topic**	**Problem set**	**Reading**
1	Tu	Aug	29	Introduction to heat transfer, modes of heat transfer		1.1-1.4
	Th	Aug	31	Control volume analysis of heat transfer problems	PSET 1 assign	1.5-1.7
2	Tu	Sept	05	Introduction to conduction, heat diffusion equation		2.1-2.3
	Th	Sept	07	Heat equation, boundary and initial conditions	PSET 2 assign PSET 1 due	2.4-2.5
3	Tu	Sept	12	Steady-state 1D heat conduction without heat generation		3.1-3.4
	Th	Sept	14	Steady-state 1D heat conduction with heat generation	PSET 3 assign PSET 2 due	3.5
4	Tu	Sept	19	Heat transfer from extended surfaces		3.6
	Th	Sept	21	Extended surfaces examples	PSET 4 assign PSET 3 due	3.7
5	Tu	Sept	26	Multi-dimensional heat conduction, lumped capacitance model (LCM)		4.1-4.3, 5.1-5.3
	Th	Sept	28	Transient 1D conduction (plane wall, long cylinder, sphere), one term approximation, Heislet chart	PSET 5 assign PSET 4 due	5.4-5.6
6	Tu	Oct	03	Semi-infinite body, product rule, 2D/3D heat conduction, product rule		5.7
	Th	Oct	05	Introduction to convection, convection boundary layer, local and average convection coefficients	PSET 6 assign PSET 5 due	6.1-6.3
7	Tu	Oct	10	Boundary layer analysis, boundary layer equations, laminar and turbulent flow, Reynolds analogy		6.4-6.7
	Th	Oct	12	External flow over a flat plate	PSET 7 assign PSET 6 due	7.1-7.3
8	Tu	Oct	17	**No class (Fall study break)**		
	Th	Oct	19	External flow, cylinder in cross flow, flow past spheres, flat plate in parallel flow	PSET 8 assign PSET 7 due	7.4-7.5

9	Tu	Oct	24	Review session Ch. 1-4, 5, 6 (PSET 1-PSET 6)		
	Th	Oct	26	**EXAM 1** **TIME: 6-8p** **PLACE: CHRYSLER AUDITORIUM** **133 CHRYSLER (6-9p, SSD)**		
10	Tu	Oct	31	Internal flow, hydrodynamic boundary layer, thermal boundary layer, energy balance, uniform wall temperature (UWT), uniform heat flux (UHF), internal flow thermal analysis, laminar and turbulent flows in tubes	PSET 8 due PSET 9 assign	8.1-8.6
	Th	Nov	02	Natural convection, governing equations, free convection on a flat plate, long cylinder, and sphere, combined free and forced convection		9.1-9.9
11	Tu	Nov	07	Types of heat exchangers, overall heat transfer coefficient, heat exchanger analysis	PSET 10 assign PSET 9 due	11.1-11.2
	Th	Nov	09	Logarithmic mean temperature difference, the effectiveness–NTU method		11.3-11.7
12	Tu	Nov	14	Review session Ch. 7-9, 11 (PSET 7- PSET 10)	PSET 11 assign PSET 10 due	
	Th	Nov	16	Blackbody radiation, emission from real surfaces, absorption, reflection, and transmission by real surfaces, Kirchoff's law, gray surface, view factor		12.1-12.8, 13.1
13	Tu	Nov	21	**EXAM 2** **TIME: 6-8p** **PLACE: CHRYSLER AUDITORIUM** **133 CHRYSLER (6-9p, SSD)**		
	Th	Nov	23	**No class (Thanksgiving recess)**		
14	Tu	Nov	28	Blackbody radiation exchange, radiation shield, reradiating surface, multimode heat transfer, participating media	PSET 12 assign PSET 11 due	13.2-13.4
	Th	Nov	30	Boiling and condensation, pool boiling, Laminar film condensation (Nusselt model), dropwise condensation		10.1-10.12
15	Tu	Dec	05	Review session Ch. 12-13	PSET 12 due	
	Mo	Dec	11	**EXAM 3** **TIME: 1:30 pm-3:30 pm** **PLACE: 1500 EECS and 1200 EECS** **SSD: 1100 Dow Conference Room**		

Selected conversion factors (SI = Multiplier × Other unit)

Dimension	**SI =**	**Multiplier ×**	**Other unit**
Density	kg/m^3	16.018	lbm/ft^3
	kg/m^3	10^3	g/cm^3
Diffusivity	m^2/s	0.092903	ft^2/s
	m^2/s	10^{-6}	centiStoke (cSt)
Energy	J	1055.04	Btu
	J	4.1868	cal
Flow rate	m^3/s	1.6667×10^{-5}	lpm
	m^3/s	6.3090×10^{-5}	gal/min (gpm)
	m^3/s	4.7195×10^{-4}	ft^3/min (cfm)
Heat flux	W/m^2	3.154	$btu/hr \cdot ft^2$
Heat transfer coefficient	$W/m^2 \cdot K$	5.6786	$btu/hr \cdot ft^2 \cdot °F$
Length	m	0.0254	in
	m	0.3048	ft
Power	W	0.022597	ft·lbf/min
	W	0.29307	btu/hr
	W	745.700	hp
Pressure	Pa	248.8	in H_2O at 60 °F
	Pa	6894.8	psi
	Pa	101325	atm
Specific heat capacity	J/kg·K	4186.9	Btu/lbm·°F
	J/kg·K	4186.8	cal/g·°C
Temperature	K	5/9×°R	
	K	°C + 273.15	
	K	(°F + 459.67)/1.8	
Thermal conductivity	W/m·K	1.7397	Btu/hr·ft·°F
	W/m·K	418.68	cal/s·cm·°c
Viscosity (absolute)	Pa·s	10^{-3}	centiPoise (cP)
	Pa·s	1.4881	lbm/ft·s
	Pa·s	47.8803	$lbf \cdot s/ft^2$

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: 2024-01-25
Effective Term: Winter 2025

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

	CURRENT LISTING			REQUESTED LISTING		
☐	Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 481			Dept (Home): Civil & Environmental Engin Subject: CEE Catalog: 481		
☐	☐ 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) Aquatic Chemistry			Course Title (full title) Aquatic Chemistry		
☐	Abbreviated Title (20 char) Aquatic Chemistry			Abbreviated Title (20 char) Aquatic Chemistry		
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Chemical principles applicable to the analysis of the chemical composition of natural waters and engineered water treatment systems; covers acid-base, precipitation-dissolution, complexation, and oxidation-reduction reactions; emphasis on graphical and analytical methods; presented in the context of contemporary environmental issues including water quality, climate change, and pollution prevention and abatement.					
☐	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					
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits: 3			☐ Course is Y graded ☐ Can be taken more than once in the same term		

Subject: Civil & Environmental Engin Catalog: 481

☐	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) Chem 130 and senior standing Minimum grade requirement: C-	Enforced Prerequisite (254 char) Chem 130 or Chem 210. or senior standing Minimum grade requirement: C-
☐	Credit Exclusions No credit granted to those who have completed or are enrolled in CEE 581.	Credit Exclusions No credit granted to those who have completed or are enrolled in CEE 581.

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

Cognizant Faculty Member Name: Brian Ellis Cognizant Faculty Member Title: Assoc. Professor

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

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

CoE Curriculum Committee Representative: Radoslaw L. Michalowski 03/18/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Print: Yafeng Yin Date: 3/18/2024

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:

Course Description
Chemical principles applicable to the analysis of the chemical composition of natural waters and engineered water treatment systems; covers acid-base, precipitation-dissolution, complexation, and oxidation-reduction reactions; emphasis on graphical and analytical methods; presented in the context of contemporary environmental issues including water quality, climate change, and pollution prevention and abatement.

Class Length
Full term

Contact hours (lecture):
3

Contact hours (recitation)

Contact hours (lab)

Requested:

Course Description
Chemical principles applicable to the analysis of the chemical composition of natural waters and engineered water treatment systems; covers acid-base, precipitation-dissolution, complexation, and oxidation-reduction reactions; emphasis on graphical and analytical methods; presented in the context of contemporary environmental issues including water quality, climate change, and pollution prevention and abatement

Class Length
Full term

Contact hours (lecture):
3

Contact hours (recitation)

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:
This change in prerequisite language is being made to allow students who have, for example, taken AP Chemistry in high school and then completed a more advanced chemistry course at UM (e.g., CHEM 210) to enroll in the course. Having the enforced prerequisite of Chem 130 currently has created instances where students who’ve completed more advanced chemistry courses are unable to register because Chem 130 is not on their transcript, even though it is a prerequisite to the more advanced chemistry courses they have completed at UM. Senior standing for undergraduates is now an advisory prerequisite, not enforced.

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Phone: 734.763.2113
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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

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

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

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

	CURRENT LISTING			REQUESTED LISTING		
☐	Dept (Home): Electrical & Computer Engineering Subject: ECE Catalog: 551			Dept (Home): Electrical & Computer Engineering Subject: ECE Catalog: 551		
☐	☐ 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) Matrix Methods for Signal Processing, Data Analysis and Machine Learning			Course Title (full title) Matrix Methods for Signal Processing, Data Analysis and Machine Learning		
☐	Abbreviated Title (20 char) Matrix Meth Sig Proc			Abbreviated Title (20 char) Matrix Meth Sig Proc		
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Theory and application of matrix methods to signal processing, data analysis and machine learning. Theoretical topics include subspaces, eigenvalue and singular value decomposition, projection theorem, constrained, regularized and unconstrained least squares techniques and iterative algorithms. Applications such as image deblurring, ranking of webpages, image segmentation and compression, social networks, matrix completion, recommender systems and handwritten digit recognition.					
☐	Full Term Credit Hours Undergraduate Min: 4 Undergraduate Max: 4	Graduate Min: 4 Graduate Max: 4		Half Term Credit Hours Undergraduate Min: Undergraduate Max:	Graduate Min: 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: Elec Engin & Computer Sci   Catalog: 551

☐	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) EECS 351 and (C or better) or Graduate Standing	Advisory Prerequisite (254 char) EECS 351 or Graduate Standing
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions Students cannot earn credit for both EECS 505 and EECS 551.	Credit Exclusions Students cannot earn credit for both ECE 505 and ECE 551.

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

Cognizant Faculty Member Name: Jeffrey Fessler   Cognizant Faculty Member Title: Professor

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

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

CoE Curriculum Committee Representative: Achilleas Anastasopoulos   Print: Achilleas Anastasopoulos   Date: 3/30/24

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Heath Hofmann   Print: Heath Hofmann   Date: 3/28/2034

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:

Course Description
Theory and application of matrix methods to signal processing, data analysis and machine learning. Theoretical topics include subspaces, engenvalue and singular value decomposition, projection theorem, constrained, regularized and unconstrained least squares techniques and iterative algorithms. Applications such as image deblurring, ranking of webpages, image segmentation and compression, social networks, circuit analysis, recommender systems and handwritten digit recognition. Applications and theory are covered in greater depth than in EECS 453.

Class Length
Full term

Contact hours (lecture):
3

Contact hours (recitation)
1

Contact hours (lab)

Requested:

Course Description
Theory and application of matrix methods to signal processing, data analysis and machine learning. Theoretical topics include subspaces, eigenvalue and singular value decomposition, projection theorem, constrained, regularized and unconstrained least squares techniques and iterative algorithms. Applications such as image deblurring, ranking of webpages, image segmentation and compression, social networks, matrix completion, recommender systems and handwritten digit recognition.

Class Length
Full term

Contact hours (lecture):
3

Contact hours (recitation)
1

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 the prerequisite wording, "and" was a typo, and anyway there is no need for us to require what grade they got in an undergraduate course. Only very brave undergraduates will take this challenging graduate course.

Regarding changing the course description, we have not covered any circuit analysis examples in the course in many years and matrix completion is a more central topic to the course. The course description wording being removed applies to the old EECS 453, not the new EECS 453.