# UNIVERSITY OF MICHIGAN
## College of Engineering
## Curriculum Committee Meeting
## Tuesday, September 26, 2023

**Attending:** Peter Adriaens, Achilleas Anastasopoulos, Jack Baker, Robert Bordley, Chris Fidkowski, Fei Gao, Saadet Albayrak Guralp, Gail Hohner, Amir Kamil, Leena Lalwani, Megan Langille, Xiaogan Liang, Cameron Louttit, Emmanuelle Marquis, Frank Marsik, Radoslaw Michalowski, Mika Panagou, Eric Rutherford, Anchal Sareen, Ben Spector, Roxanne Walker

**Support Staff:** Mercedes Carmona, Besty Dodge, Matthew Faunce

**Call to Order: 1:35PM**

**Adjourned: 2:29 PM**

**Agenda:**

1. Approval of 9.12.2023 Meeting Minutes (Page 3) - **APPROVED**
2. M Eng Smart Infrastructure Finance Program Curriculum Modifications – Action Item (Page 7) - **APPROVED**
    a. The original M Eng Smart Infrastructure Finance program was approved in 2018 and implemented in 2019-2020 and 2020-2021. Ross School of Business then requested, after discussions internally with the Interim Dean and Finance faculty, that the required core courses be removed from the program curriculum due to no longer wanting to participate. Ultimately, the core classes have been altered as well as the electives for the program. These new proposed changes are to be effective for Fall 2024.
        i. Core Classes
            1. Old/Removed Courses: TO 640, FIN 428
            2. New Courses: CEE 504 or 531, CEE 555 or 501.001, CEE 575 or CEE 533, CEE 553 or IOE 561, CEE 503
        ii. Electives
            1. Old/Removed Courses: FIN 480, FIN 624, PUBPOL 750 Section 008/009
            2. New Courses:
                a. Data Science Options: IOE 541, CEE 435
                b. Finance Options: PUBPOL 744, IOE 453, IOE 455, PUBPOL 715 Section 001
    b. A member inquired if the courses were already listed for the program. Courses are listed and there are some still being submitted, such as CEE 503, which is on the agenda for review and approval today.
3. Non-Attendance Drop Statement Proposal – Action Item (Page 17) - **TABLED**
    a. The CoE RO received an inquire whether instructors could administratively drop a student for non-attendance or inactivity from a course.
    b. CoE does not have a policy that directly relates to this, but LSA does have a policy statement that can be viewed. The URO said theoretically this request could be done, but there needs to be an official vote and agreement on a policy that directly states this in the CoE Bulletin. The CoE RO is reaching out to CoE CC members to further elaborate on this and possibly come to an agreement or not regarding this Non-Attendance Drop for students.
    c. Currently, CoE instructors can issue a grade of ED, which is equivalent to an unofficial drop meaning the student never participated. ED is calculated into the student's GPA as a failing grade. This is a mechanism that has been used, but ultimately there should be policy in place.
    d. A member asks if this is a common issue that is affecting students. Students are aware of tuition costs so they would find a way to drop a course if needed. There is no specific data at hand as to how many students are being affected by this. Another member says this is probably for a rare number of students and gives examples of courses (ENGR 100, ME 235) that could be used, as do other members.

e. The main issue, a member brought up, is group project participation and lack of a student participating ultimately hurting this group's chance of fully having active participation and learning experiences due to the student's non-attendance/inactivity.
f. The EECS Department had similar language to LSA regarding non-attendance from students within their courses. This language seemed to scare students as they thought this was negative and would be penalized in a way down the road. Ultimately, the language was removed by the department as a result to lessen the burden if a student had to miss the first week or day of classes.
g. A member asks if this policy would be about attendance or general participation for a course. With a new policy created, this could include all information about participation from a student, but there would need to be an agreement on what attendance or participation means. In this case, this may be a DEI Issue at hand, which would be a bigger issue at hand.
h. Suggestion of an intermittent step that if a student doesn't participate would be to have the EAC send an email and await the student's response before additional steps are taken to ultimately drop the student. This would help with group projects and participation needed for the duration of the course.
    i. There would then need to be a predetermined time as to when this step is to be implemented and not wait till the end of the semester.
i. There was an agreement that CoE Members are to speak within their departments about this policy and next meeting discuss what they inquired.
j. This proposal will be tabled until the next CoE CC meeting on 10.10.2023.

4. Review of Professional or Creative Development Courses (PCDC) Degree Audit Rule – Informational Item (Page 18) – **TABLED**
    a. The CoE RO is reaching out about Degree Audit Rules with Intellectual Breadth (IB) for PCDC and Humanities (HU) Credits and how some courses should be listed and counted for a student's degree audit when a course is listed for both PCDC and HU.
        i. 16 IB Credits, which include:
            1. PCDC credits are optional and are no more than 4 credits.
            2. HU credits are at least 3 credits based off the LSA Course Guide, and credit by test cannot be used for this requirement.
            3. 300-level LAC are at least 3 credits of LAC 300 level or higher courses. Students may satisfy the HU and 300 level requirements with a single course.
    b. Example: PUBPOL 200 (4 credits) listed as PCDC and ARCH 215 (4 credits) listed as PCDC and counts to HU. With PUBPOL 200, the student would then have 4 PCDC credits that can be counted toward 16 IB credits. In the student's audit, what then should happen to ARCH 215? A few options were given.
        i. ARCH 215 should NOT count toward the 3 credits of HU requirement and should NOT count toward 16 IB credits.
        ii. ARCH 215 should count toward the 3 credits of HU but should NOT count toward the 16 IB credits. The student would then need 3 additional credits to count toward the 16 IB credit total.
        iii. ARCH 215 should count toward BOTH HU and 16 IB credits even though the 4 credits max had been met with PUBPOL 200. Therefore, the HU designation negates the PCDC designation.
            1. This suggestion is the current understanding of IB credits and degree audits. The CoE RO would like to know whether to continue to follow this or follow the rule that says HU courses should not be allowed in PCDC.
    c. Questions as to what the history is behind 4 credits needed to exist as a PCDC max as well as if HU has a higher priority than PCDC designation. Also, if there are any other requirements missing or an agreement with CoE and LSA regarding the IB credits that can be provided before this is voted upon members. No information given at hand but can be discussed with RO as well as faculty members, Fred Terry and Susan Montgomery.
        i. Susan was approached regarding this topic. Says there may have been confusion whether a course that was both PCDC and HU and how to determine which slot to fulfill and as a result chose the HU slot. If that wasn't the case, then it was best to have the audit match the bulletin.
            1. The preferred method would be to prioritize a HU category course to the HU slot first. Then, the PCDC course could have the HU associated with it.
    d. There was an agreement that CoE Members are to do more reading and gain information before voting and discuss more at the next meeting.
    e. This proposal will be tabled until the next CoE CC meeting on 10.10.2023.

| PAGE | SUBJECT | COURSE # | ACTION | SUMMARY | EFFECTIVE TERM | MIN. GRADE REQ. FOR ENF. PREPREQ | IS COURSE ON LSA COURSE GUIDE? | APPROVED | NOTES & REVISIONS | TABLED |
|---|---|---|---|---|---|---|---|---|---|---|
| 20 | CEE | 211 | MOD | Change to Course Description. | WT 2024 | NO | NO | APPROVED | | |
| 23 | CEE | 503 | NEW | | WT 2024 | NO | NO | CONDITIONAL APPROVAL | Course Description needs to have course topics listed out. | |
| 39 | CEE | 526 | MOD | Change to Course Description and Course Components. | WT 2024 | NO | NO | APPROVED | Correction of Faculty Name and Signature. | |
| 42 | EECS | 440 | DEL | | WT 2024 | C | YES | APPROVED | | |
| 45 | EECS | 448 | MOD | Change to Advisory Prerequisite. | WT 2024 | C | YES | APPROVED | | |
| 48 | ENGR | 255 | MOD | Change to Full Term Credit Hours. | WT 2024 | NO | YES | APPROVED | | |
| 51 | ENGR | 455 | MOD | Change to Full Term Credit Hours and Repeatability. | WT 2024 | NO | YES | APPROVED | | |
| 54 | NAVARCH | 332 | MOD | Change to Course & Abbreviated Title and Advisory Prerequisite. | WT 2024 | NO | NO | CONDITIONAL APPROVAL | Advisory Prerequisites need to be correctly listed (NA, ME to NAVARCH, MECHENG). | |
| 57 | NAVARCH | 340 | MOD | Change to Advisory Prerequisite. | FT 2024 | NO | NO | CONDITIONAL APPROVAL | Advisory Prerequisites need to be correctly listed (NA, ME to NAVARCH, MECHENG). | |
| 60 | NAVARCH | 420 | DEL | | WT 2024 | NO | NO | CONDITIONAL APPROVAL | Cross listed with CLIMATE 420 and ENSCEN 420. Advisory Prerequisites need to be correctly listed (NA to NAVARCH). | |
| 63 | NAVARCH | 475 | MOD | Change to Advisory & Enforced Prerequisites. | FT 2024 | C- | NO | CONDITIONAL APPROVAL | Advisory Prerequisites need to be correctly listed (NA to NAVARCH). | |
| 66 | ROB | 511 | MOD | Change to Course & Abbreviated Title, Course Description, Advisory Prerequisite, Credit Exclusions, Course Components. | WT 2024 | NO | NO | CONDITIONAL APPROVAL | Follow up if ROB 511 needs to be listed in Credit Exclusions and Enforced Prerequisite needs to have Graduate Standing. | |

**UNIVERSITY OF MICHIGAN**
**College of Engineering**
**Curriculum Committee Meeting**
**Tuesday, September 12, 2023**

**Attending:** Achilleas Anastasopoulos, Jack Baker, Miki Banu, Robert Bordley, Yavuz Bozer, Chris Fidkowski, Fei Gao, Brent Gillepsie, Saadet Albayrak Guralp, Amir Kamil, Leena Lalwani, Xiaogan Liang, Cameron Louttit, Frank Marsik, Radoslaw Michalowski, Eric Rutherford, Anchal Sareen, Ben Spector, Roxanne Walker

**Support Staff:** Mercedes Carmona, Betsy Dodge, Matthew Faunce

**Call to Order:** 1:36 PM

**Adjourned:** 2:18 PM

**Agenda:**

1. Approval of 8.29.2023 Meeting Minutes (Page 4) - **APPROVED**
2. Voting for CoE Curriculum Committee Chair for 2023-2024
    a. Xiaogan Liang nominated and unanimously voted upon by Curriculum Committee to be the chair for the next academic year.
3. HLC Annual Audit Process (Page 12)
    a. Engineering RO's Office breaks down HLC Annual Audit Report, created by University Registrar Office, by department and unit by matching previous term's courses that did not meet the CoE Policy for the Assignment of Credit Hours or did not cancel previous sections that were not in compliance.
    b. Spreadsheets, sent by Xiaogan last Friday September 8, were sent to Department Undergraduate and Graduate Chairs, UA's, and Curriculum Maintainers and given a one month deadline to correct courses found in the report that are not in compliance
        i. It is the responsibility of the UG and Grad. Chairs to speak to their departments regarding the report to review the information and send back a completed spreadsheet.
            1. The spreadsheet will be used to confirm that courses for the following term comply with the CoE Policy for the Assignment of Credit Hours.
                a. Courses that can be easily fixed can be done within the department and marked in the spreadsheet.
                b. Courses that cannot easily be fixed will need to input that information in the form of a questions and recorded in the spreadsheet. This will later be addressed by the CCC.
                c. The CCC will meet and discuss at their next scheduled meeting the spreadsheets' questions, course categories, and consult with curriculum experts if needed.
                d. If needed, the CoE Policy for the Assignment of Credit Hours will then be updated based on the results of these questions and discussions.
    c. A member inquired if the departments from the report have met the requirements for labs and hours. Xiaogan said yes and most followed the CoE Policy for the Assignment of Credit Hours. There were some courses that did not follow the policy and it was logged in the spreadsheet.
    d. After Xiaogan showed the spreadsheet referenced to the report that needs to be updated by departments, some CCC members asked if they could receive access to the spreadsheet and be included in emails.
        i. CoE RO to follow up for department members to receive information
4. ISD DENG Modification of Existing Engineering Program Proposal (Page 14) – Action Item - **APPROVED**
    a. Admission tracks modifications requested to the current Doctor of Engineering in Manufacturing (D Eng in MFG):

i. Admitted directly to the D. Eng in MFG without a relevant master's degree must complete the Master of Engineering in Manufacturing (M Eng in MFG requirements along with an "Embedded Master"
    1. A student may count up to 18 letter-graded (A-E) credits from the 30 credit M Eng in MFG toward the 18 letter-graded (A-E) credits.
        a. Excluded courses: MFG 990, 995, 590, 503, ELI Courses
    2. At least 6 credits of letter graded (including the grade S-Satisfactory) graduate coursework registered under Graduate Engineering.
    3. Students completing the M Eng in MFG requirements while also meeting the D Eng in MFG requirements have the option to receive the M Eng in MFG degree and discontinue from the D Eng in MFG and only complete M Eng in MFG.

ii. Admitted with a master's degree in the same or relevant field from another institution – Not a U of M Degree (master's in engineering, business)
    1. Manufacturing Program Committee or the Program Director will validate the relevance of the existing master degree
    2. Fulfill 18 letter-graded credits (A-E) and 6 additional credits

iii. Admitted with a master's degree in the same or relevant field from U of M (i.e., change of program students) (M Eng in MFG, master's in engineering, business)
    1. Fulfill 18 credits with at least 6 credits letter-graded (included the grade S-Satisfactory)
    2. Program committee together with program director will analyze and decide how many letter-graded credits (A-#) from U of M master may be counted toward the D Eng in MFG program (maximum of 2 course from U of M master may be counted)

b. Amends to current D Eng in MFG double-counting and transfer credit rules:
    1. No double counting restriction between M Eng in MFG and D Eng in MFG
    2. A student may transfer up to 6 approved credits (Non-U of M Credits)
    3. Rackham PhD Transfer of credit rules applied.
        a. These credits do not appear on a transcript, although meeting the degree requirement with Non U of M credits, and will not count toward overall 18 letter-graded (A-E) credits.
        b. The student will need to take additional credits to meet the D Eng in MFG 18 letter-graded A-E credits.

c. A member inquired if the same director is who evaluates both the M Eng in MFG and D Eng in MFG programs. Miki said the Program Director is the same for both programs and completes student evaluations.

| PAGE | SUBJECT | COURSE # | ACTION | SUMMARY | EFFECTIVE TERM | MIN. GRADE REQ. FOR ENF. PREPREQ | Is Course on LSA Course Guide? | APPROVED | NOTES & REVISIONS | TABLED |
|---|---|---|---|---|---|---|---|---|---|---|
| 26 | IOE | 316 | MOD | Change to Enforced Prerequisite. | FT 2024 | C- | YES | APPROVED | | |
| 29 | IOE | 431 | NEW | | WT 2024 | NO | NO | APPROVED | | |
| 42 | IOE | 435 | NEW | | FT 2024 | C- | NO | APPROVED | Cross listed with ROB 435. Member will check why Non-Rackham students excluded. | |
| 66 | IOE | 562 | DEL | | WT 2024 | NO | YES | APPROVED | Cross listed with STATS 535. | |
| 69 | NERS | 441 | MOD | Change to Enforced Prerequisite. | FT 2024 | C | YES | APPROVED | | |

## EECS CARFs with Subject Changes to ECE or CSE – Bulk Review

| PAGE | SUBJECT | COURSE # | ACTION | SUMMARY | EFFECTIVE TERM | MIN. GRADE REQ. FOR ENF. PREPREQ | Is Course on LSA Course Guide? | APPROVED | NOTES & REVISIONS | TABLED |
|---|---|---|---|---|---|---|---|---|---|---|
| 72 | EECS | 513 | MOD | Change to Advisory Prerequisite. | FT 2024 | NO | YES | APPROVED | | |
| 75 | EECS | 517 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with NERS 578. | |
| 78 | EECS | 524 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with APPPHYS 524. | |
| 81 | EECS | 530 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with APPPHYS 530. | |
| 84 | EECS | 532 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with CLIMATE 587 and SPACE 587. | |
| 87 | EECS | 537 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with APPPHYS 537. | |
| 90 | EECS | 540 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with APPPHYS 540. | |
| 93 | EECS | 541 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with APPPHYS 541. | |
| 96 | EECS | 546 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with APPPHYS 546. | |
| 99 | EECS | 552 | MOD | Change to Advisory Prerequisite. | FT 2024 | NO | YES | APPROVED | Cross listed with APPPHYS 552. | |
| 102 | EECS | 560 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with AEROSP 550, CEE 571, and MECHENG 564. | |
| 105 | EECS | 562 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with AEROSP 551. | |
| 108 | EECS | 569 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with MFG 564. | |
| 111 | EECS | 586 | MOD | | FT 2024 | B+ | YES | APPROVED | | |
| 114 | EECS | 596 | MOD | Change to Course Description and Advisory Prerequisite. | FT 2024 | NO | YES | APPROVED | | |

| PAGE | SUBJECT | COURSE # | ACTION | SUMMARY | EFFECTIVE TERM | MIN. GRADE REQ. FOR ENF. PREPREQ | Is Course on LSA Course Guide? | APPROVED | NOTES & REVISIONS | TABLED |
|---|---|---|---|---|---|---|---|---|---|---|
| 117 | EECS | 600 | MOD | Change to Advisory Prerequisite. | FT 2024 | NO | YES | APPROVED | Cross listed with IOE 600. | |
| 120 | PSYCH | 643 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with EECS 643. | |
| 124 | PSYCH | 644 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with EECS 644. | |
| 127 | EECS | 662 | MOD | Change to Advisory Prerequisite. | FT 2024 | NO | YES | APPROVED | Cross listed with AEROSP 672 and MECHENG 662. | |
| 130 | PSYCH | 740 | MOD | | FT 2024 | NO | YES | APPROVED | Cross listed with EECS 695. | |

# *MEng Smart Infrastructure Finance Memo*

## *Summary of Curriculum Changes*

To: Curriculum Committee, College of Engineering

From: Peter Adriaens, Professor CEE and Program Director, MEng Smart Infrastructure Finance

Date: September 17, 2023

Re: Summary of curriculum changes, MEng Smart Infrastructure Finance

Dear Colleagues,

The original MEng program was approved by all required committees in 2018, and first implemented in AY 2019-20 and 2020-21, when the Ross School of Business requested that required courses (core) would be removed from the curriculum. During the following year, internal meetings in CEE, with IOE and the School for Public Policy resulted in a change in the core program, as well as electives offered effective Fall 2024.

The main change is to remove Ross courses from core, to offer all core courses in CEE/IOE, and to increase electives in CEE/IOE. These changes (in red) have been approved by the CEE curriculum committee and the CEE faculty, and are summarized below:

| | Old | | New |
|---|---|---|---|
| ***Core (choose 5)*** | | ***Core (choose 5)*** | |
| 1 | CEE 501.001 - Introduction to Smart Infrastructure Systems (Winter 2022) | 1 | CEE 504 - Engineering Economics and Finance (Fall) **or** CEE 531 - Construction Cost Engineering (Fall) |
| 2 | CEE 504. - Engineering Economics and Finance (Fall) | 2 | CEE 555 - Sustainable Civil Infrastructure Systems (Fall) ***or*** CEE 501.001 – Introduction to Smart Infrastructure Systems (Winter) |
| 3 | CEE 501.004 - Infrastructure Project Finance (Winter) | 3 | CEE 575 - Sensing for Civil and Environmental Engineering (Fall) **or** CEE 533 - Engineering Process Modeling and Risk Analysis |
| 4 | IOE 561 - Risk Analysis I (Fall) or equivalent | 4 | CEE 553 - Infrastructure Systems Optimization (Fall) **or** IOE 561 - Risk Analysis I (Winter) |
| 5 | TO 640 - Big Data Management (Winter) or equivalent | 5 | CEE 503 - Infrastructure Project Finance (Winter) |
| 6 | Fin 428 - FinTech Innovations (Winter) | | |
| ***Electives (choose 3)*** | | ***Electives (choose 3)*** | |
| Data Science Options (when available) | | Data Science Options (when available) | |
| 1 | CEE 575 - Sensing for Civil and Environmental Engineering (Fall) | 1 | EECS 545 - Machine Learning (Fall/Winter; Prereq EECS 592 – Intro Art Intelligence) |
| 2 | CEE 553 - Infrastructure Systems Optimization (Fall) | 2 | CEE 572 - Dynamic Infrastructure Systems (Fall; Prereq Math 417) |
| 3 | EECS 545 - Machine Learning (Fall/Winter; Prereq EECS 592 – Intro Art Intell) | 3 | CEE 554 - Data Mining in Transportation (Winter) |
| 4 | CEE 572 - Dynamic Infrastructure Systems (Fall; Prereq Math 417) | 4 | *new* IOE 541 - Optimization in Supply Chains (Fall) |
| 5 | ENG 520 - Entrepreneurial Business Fundamentals (Winter) | 5 | *new* CEE 435 – Building Information Modeling (Fall; Prereq CEE 431 or Graduate Standing) |
| 6 | CEE 554: Data Mining in Transportation (Winter) | | |
| Finance Options (when available) | | Finance Options (when available) | |
| 1 | CEE 588 - Environmental Finance (Fall) | 1 | CEE 588 - Environmental Finance (Fall) |
| 2 | Fin 583 - Energy Project Finance (Winter) | 2 | Fin 583 - Energy Project Finance (Winter) |
| 3 | FIN 480 - Options and Futures in Financial Decision Making (Winter) | 3 | *new* PubPol 744 – Economics of the Public Sector (Winter) |
| 4 | FIN 624 – Private Equity (Fall) | 4 | *new* IOE 453 - Derivative Instruments (Fall) |
| 5 | PUBPOL 750-section 008/009 - FinTech Entrepreneurship (Fall/Winter term) | 5 | *new* IOE 455 - Corporate Finance (Fall) |
| | | 6 | *new* PubPol 715.001: Budgeting and Financial Planning (Winter) |

# Master of Engineering
# Smart Infrastructure Finance (SIF)

**Core Faculty**

Program Director: Peter Adriaens (CEE)

Professors: Seth Guikema (IOE/CEE), Glen Daigger (CEE), Vineet Kamat (CEE), Carol Menassa (CEE), Branko Kerkez (CEE), SangHyun Lee (CEE), and Yafeng Yin (CEE)

## A. Summary

The Master of Engineering (MEng) degree in Smart Infrastructure Finance is a one-year (26 credit + 1 credit internship) program that offers students a professional degree oriented towards data-driven finance and business models for smart and resilient infrastructure designs. The Program supports a student pipeline for the new Center for Digital Asset Finance. More detail on this center can be found at https://www.difin.io.

This one-year degree program is targeted at students who hold a B.S. degree and/or equivalent experience in civil and environmental engineering, business, policy and law. The anticipated off-take market for this degree program includes construction engineering, consulting or financial services (e.g. banking, insurance, private equity) after completion of their degree.

The MEng in Smart Infrastructure Finance will enable students to:

- *Explore the Innovation Opportunity of Smart Infrastructure as an Asset Class*
- *Develop Performance Benchmarks Based on Infrastructure Characteristics*
- *Understand How Data Facilitate Risk Management in Infrastructure Investment*
- *Categorize Data Types, Their Value and Pricing in the Marketplace*
- *Develop and Test Financial Models to Capture the Value from Data*
- *Inform Infrastructure Designs that Target Financial and Resiliency Objectives*
- *Participate in a Required Internship with our Infrastructure Finance Partners*

Students in the SIF Program will be required to take 5 core courses in infrastructure, finance and data analytics, as well as an elective concentration drawn from three areas: business models, financial theory and models, and data science tools. It is not the intent of this document and the course offering to be too prescriptive, but rather to allow the student to tailor the program to their expertise and interest, in consultation with the program advisor. An internship in financial services or the broadly defined smart infrastructure industry is part and parcel to the program.

## B. Motivation: Smart Infrastructure and Data

Built and natural infrastructure systems underlie the largest sectors and GDP enablers of the economy being disrupted by ‘smart designs’. In large part this is due to the integration of ubiquitous sensing devices and enterprise software, as well as new materials, to improve operations, increase efficiencies, and reduce risk for construction companies and investors. Smart infrastructure is up-ending industry supply chains as well as information data streams, resulting in the emergence of valuable digital supply chains.

This requires companies (see Section C.) to retool, seek out new partnerships, and develop data-driven business models (DDBMs). From transportation, commercial and residential buildings, water conveyance and treatment systems, energy facilities, and the agro-economy, hard assets are increasingly integrated with enterprise software and data processing capabilities. This not only impacts design methods and life cycle analysis, or building information modeling (BIM), but is redefining infrastructure as a service product.

The industry refers to smart infrastructure as: "*The business of interdependence, with cross-industry 'handoffs' of data in virtually-connected sustainable infrastructure systems to develop new customer value propositions and new business models*".

The investment management industry has capitalized on the data trend. Infrastructure is data, business models are increasingly based on data, and investment models are structured around data trends. For example, digital platforms such as block chain are being explored to disrupt financing of sustainable cities, water and energy provision in developed and developing economies. In addition, ESG (environmental, social and governance) risk criteria are becoming integrated in investment decision making around project finance, green bonds, and other asset classes. This so-called financial technology (FinTech) megatrend is at the cusp of unplugging new capital flows towards investment in infrastructure systems.

The opportunity addressed here is that data can help bridge the infrastructure finance gap, unlock efficient capital, and democratize investment for more equitable distribution of quality of life across communities.

Civil and environmental engineers have traditionally focused on financial decision tools and models such as net present value (NPV) and discounted cash flow (DCF). More recently, life cycle cost analysis (LCCA) and the integration of environmental externalities has become part of the decision toolbox. The time is right to connect the design of smart infrastructure systems with the financial opportunities they offer.

### C. CEE Opportunity: Building New STEM Skillsets for Emerging Profession

*With CEE at the center of intelligent infrastructure innovations, the integration of infrastructure finance skillsets in the discipline leverages the transition from product- to data-centric values.*

The American Society for Civil Engineers (ASCE) and the International Water Association (IWA) are calling for new infrastructure finance models such as public/private partnerships (P3), securitization, insurance and impact bonds that capitalize on data streams. In addition, blockchain uses for evidence-based decision making in catchments, water utilities, as well as transportation and building infrastructure are being explored in mainstream venues. New applications are emerging with companies including Ferrovial, Cintra, Bentley Systems, WSP, Blockchain Triangle and Integrated Roadways.

Pilot and full-scale applications are being implemented as well. For example, DC Water has financed green infrastructure deployment using an impact bond with interest rates tied into performance measurements. The Michigan DOT is demonstrating a 65-mile connected roadway pilot with Sidewalk Infrastructure Partners by integrating digital infrastructure in public assets (e.g. I-94) between Corktown and Ann Arbor. Cisco announced a $1 bn. smart cities debt and equity program to implement smart sustainable infrastructure with less pollution, safer streets, and better quality of life for citizens. IBM Water, EcoLab and Microsoft have been working on a data-driven investment strategy for aquifer restoration, water body and quality monitoring, and pricing models for water infrastructure services. Executive education workshops in Singapore, the UK and the EU are focused on building digital twins to improve services and construction for smart roads, bridges and buildings, adaptive to the needs of next-generation construction and operations.

Multi-lateral organizations such as the UN Department of Economic and Social Affairs (DESA), which is responsible for implementation of the sustainable development goals (SDGs), is discussing smart infrastructure as part of the solution. The UN indicated the need for retraining its staff in new financing models in Doha, Qatar. Civil engineers, economic developers, and financiers are actively exploring the 'beyond public finance' paradigm of infrastructure. The European Investment Bank (EIB), Asia Development Bank, Asia Infrastructure Investment Bank and Canadian Infrastructure Bank are exploring pilots to capture data assets from connected infrastructures (roads, buildings, energy) into new data contract mechanisms for financing. More recently, the Bank for International Settlements has been prototyping digital platforms for green bond tokenization and infrastructure finance.

### D. What related programs exist?

Educational programs in infrastructure project finance are new to the engineering discipline and have evolved from the integration of business and policy disciplines with engineering skillsets. No integrated educational programs targeted to infrastructure finance currently exist at UM or in Michigan, except for the CEE MEng that has been offered twice (2020-21; 2021-22). The UM campus offers several discipline-specific research programs focused on the integration of data science, industry value chains, and finance,

through the Center for Digital Asset Finance (CEE), the Ross School of Business (Center for Value Chain Innovation; FinTech Initiative), and the Law School (Center for Finance, Law and Policy).

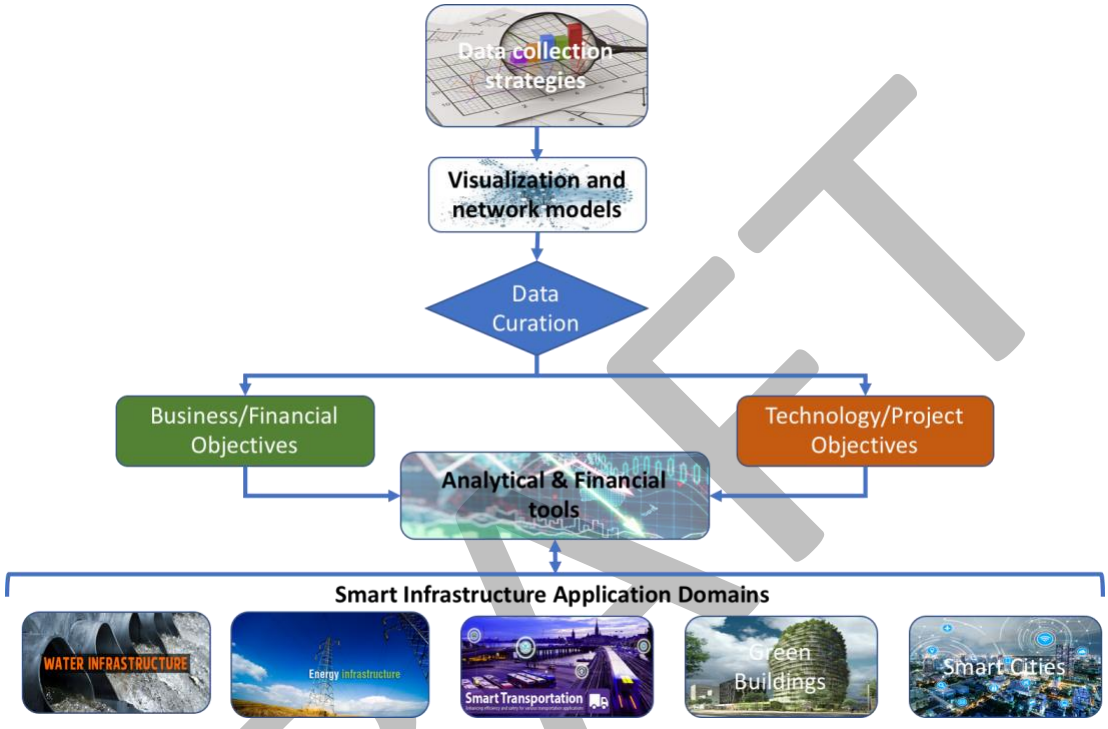
Student interest in financial technology programs is expanding. The student FinTech and Cryptocurrency Clubs, comprised of engineers and business school students, each have memberships of 150+ students, easily the largest on campus. The objective is to advance block chain-based transaction models and other digital finance opportunities across industry applications, including infrastructure.

Nationally and internationally, there are a few related programs. Stanford University's Global Projects Center, affiliated with its Civil and Environmental Engineering Program, seeks to facilitate understanding of the financing, development, and governance of critical infrastructure worldwide through interdisciplinary research, engagement with industry leaders, and education of future leaders within the infrastructure finance and development space. The University of Maryland - Department of Civil and Environmental Engineering has a Build America Center focused on "innovative financing and delivery for transportation infrastructure." Its mission is to help the Federal Highway Administration (FHWA) and the Build America Bureau to perform cutting-edge research related to innovative financing, project delivery, and policies. The Illinois Institute of Technology hired several civil engineering faculty with backgrounds in finance and derivatives in its Business School. Colombia University's Water Center has faculty focused on risk finance associated with water infrastructure and water-dependent businesses. Oxford University has a Center for Stranded Assets, which takes a finance approach to risk associated with natural and built infrastructure systems. Aside from Stanford and Oxford, no systemic programs are available that build on CEE skills and integrate data science and finance in the core disciplines.

### E. Curriculum Design

Audience: The proposed MEng program is intended to attract a multi-disciplinary audience into the discipline, in addition to CEE graduates. All students admitted in the program will have to adhere to the CEE undergraduate requirements detailed in Section F. The two pilot years have engaged students from engineering, business, policy and economics, as well as professional students. Upon graduation, these students have found employment at accounting firms, private equity funds and real estate investment trusts (REITs), as well as technology firms.

Program overview. A generic flowchart overview of the smart infrastructure program is provided in Figure 1. Students will be trained in data collection, visualization, and analytical/financial tools to develop decision models that integrate business/financial and technology/project objectives in a number of infrastructure application domains. The application domain will be developed in cooperation with the internship program. A final report after the internship program will be designed to demonstrate that the student has mastered the integration of data science/finance/smart infrastructure elements.




At least 50% of the course work needs to be completed in CEE. The students need to fulfill a core requirement of 5 courses and an elective concentration of 3 courses, in addition to attendance at seminar series and completion of a for-credit internship course (CEE 505).

***Figure 1. Organizational curricular structure of SIF MEng***

Credit Hours Distribution. A minimum total of 26 credit hours (excluding a for-credit internship course) is required to complete the MEng (Smart Infrastructure Finance) degree. Students will be exposed to intelligent infrastructure systems, data science and finance faculty members so they have an opportunity to gain maximum benefit from the program and the resources that support it.

### F. New Courses:

Four new courses have been developed to support the MEng program

1) *CEE 504. Engineering Economics and Finance.* Engineering Economics and Finance focuses on evolving financial decision making in engineering practice. Topics like accounting, public and private investment decision making, project management and risk and uncertainty are covered and linked to practical problems that are meaningful to (smart) infrastructure systems and the student's professional future.
2) *CEE 505. Smart Infrastructure Finance Internship.* The course consists of a 6-week internship at financial service, data analytics or construction/project development firms. The internship work is supplemented by a required workplan/approach and final report deliverable to the SIF MEng committee.

3) *CEE 503. Infrastructure Project Finance.* Course discusses project financing approaches, including municipal bonds, debt and equity finance, public private partnerships, securitization of revenue, and other mechanisms used to finance public and private infrastructure. The latter part of class emphasizes digital financing mechanisms such as Infratech bonds and tokenized green bonds, and asset-backed securities public private partnerships (ABS-PPP). Multiple use cases are used to illustrate the mechanisms, including toll roads, desalination plants, ballparks, ports, and mass transit.
4) *CEE 501.001. Introduction to Smart Infrastructure Systems.* This course introduces students to systems analysis of infrastructure. What is an infrastructure system in the context of analysis, data acquisition and performance evaluation? Connected infrastructures are a new concept in systems analysis, exhibiting cascading risks and effects that influence design and financing options.

### G. Curriculum

*Core Courses (15 credit hours):* All students must complete courses in a recommended set of 5 topical areas covering infrastructure systems and financial concepts in capital budgeting, financing instruments, and financial technology integration, as well as analytical tools with exposure to data visualization, optimization, stochastic processes, and statistics. If courses are not available each year or semester, similar elective courses can be taken as alternatives with the approval of the advisor.

1. **Engineering Economics & Finance: CEE 504** - Engineering Economics and Finance or **CEE 531** - Construction Cost Engineering
2. **Infrastructure as a System: CEE 555** - Sustainable Civil Infrastructure Systems **or CEE 501.001** – Introduction to Smart Infrastructure Systems
3. **Infrastructure Internet of Things (IoT): CEE 575** - Sensing for Civil and Environmental Engineering **or CEE 533** - Engineering Process Modeling and Risk Analysis
4. **Optimization/Scenario Modeling: CEE 553** - Infrastructure Systems Optimization or **IOE 561** - Risk Analysis I
5. **Infrastructure Finance: CEE 503** - Infrastructure Project Finance (cross-listed with Public Policy School – course number to be assigned)

*Electives/Concentration Areas (9 credit hours):* In addition to the core courses, each student must take 3 elective courses from 2 areas chosen in consultation with the Program Advisor in the following concentration areas (example courses are shown below). Students must have completed prerequisite courses or receive consent from instructor.

**Data Science Options**

1. **EECS 545** - Machine Learning (Prereq EECS 592 – Intro Art Intell)
2. **CEE 572** - Dynamic Infrastructure Systems (Prereq Math 417)
3. **CEE 554** - Data Mining in Transportation
4. **IOE 541** - Optimization Methods in Supply Chain
5. **CEE 435** – Building Information Modeling (Prereq CEE 331/Graduate Standing)

**Finance Options**

1. **PubPol 744** – Economics of the Public Sector
2. **PubPol 715.001**: Budgeting and Financial Planning
3. **CEE 588 -** Sustainability Finance: Investment Models for Green Growth
4. **IOE 453** - Derivative Instruments
5. **IOE 452 (MFG 455)**- Corporate Finance
6. **Fin 583** - Energy Project Finance

*Seminar Participation (2 credit hours):* Students are required to attend a seminar course aligned with the core and electives of the program to become exposed to experiential knowledge from professionals in the construction, finance, management, or data science industries. When seminar courses are not available for credit, the student needs to enroll in a comparable independent study assignment focused on a topic of

choice related to infrastructure financing. The seminar selection or independent study must be approved by the MEng student advisor. An independent study can be spread over two semesters.

### H. Requirements

Students holding B.S. degrees in an engineering discipline, or a physical or social science, may be admitted if they have achieved the technical background necessary to pursue advanced work in the SIF program. This background includes one year of college-level calculus, one year of college-level physical science, one semester engineering-level probability and statistics and one semester computer programming. More specifically, it is expected that applicants will have successfully completed the following courses in their undergraduate preparation prior to applying:

- Physics 140 (mechanics) and 240 (electricity and magnetism) or equivalents
- Mathematics 215 (multivariable calculus) and 216 (differential equations) or equivalent
- CEE 373 (probability and statistical methods) or equivalent
- CEE 303 (computational methods) or equivalent

If an admitted applicant has not completed these courses, some additional undergraduate coursework may be required to be completed (without credit) to complete the MEng. degree in Smart Infrastructure Finance. In such situations, the specific additional courses to be completed will be determined by the MEng Advisor for the SIF specialization.

### K. General Program Requirements and Policies

Students must have completed three semesters of calculus and one semester of physics or equivalent. They should also have completed a semester of statistics (e.g. CEE 373. Statistical Methods for Data Analysis and Uncertainty Modeling or equivalent). Students lacking this background will need to complete prerequisite courses before formal admission into the program.

Credit hours and normal progress: A minimum of 26 credit hours of acceptable graduate work must be completed for the MEng degree. Twelve regular course credits plus a one credit seminar is the usual full-time course load per semester. It is recommended that students plan to complete all of the courses required for the MEng degree in two regular semesters. Grades: The grade point average for the 26 hours of courses used to fulfill the requirements for the MEng degree program must be equivalent to at least a straight B (3.00). Grades below C (2.00) are not acceptable for graduate credit but are considered for the student's grade point average.

Time limit: A student must complete all work within a period of three consecutive years after first enrollment in the MEng degree program.

Graduate transfer credit: A maximum of two graduate courses equivalent to those offered in the core or elective component of the SIF Program may be transferred from another institution. These must be from graduate level courses taken either in residence or on-line with a grade of B or better from an accredited institution approved by the Rackham School of Graduate Studies. Students may request the transfer of such credits through the CEE Department after completion of one semester in the MEng program.

Undergraduate transfer credit: No undergraduate transfer credits are allowed for the MEng program, and prerequisites required for the core or elective coursework will not be counted towards final degree credits. An exception can be made by the program director for 400-level courses that are equivalent in content to core of elective coursework. These decisions will be made by the program director, in coordination with the cognizant faculty member of the SIF course that the student seeks to replace. However, 400-level courses that are required in the current undergraduate degree programs of the Department of Civil and Environmental Engineering or other undergraduate programs where the student graduated cannot be used for MEng graduate credit.

Internship course (CEE 505; 1 credit hour; 6 weeks or as structured by hosting company). All students will be required to participate in an internship program during the Spring or Summer term at companies within

the financial services, data management, or smart infrastructure industries. The internship will be for credit and will provide for professional exposure across non-traditional CEE industries.

Priority will be given to financial services companies such as MSCI, Nephila Advisors, Credit Spectrum, Dana Investment Advisors, Silicon Valley Bank, BlackRock, and NGOs such as WWF-Finance, Ceres, and WRI-Finance. These companies have paid internships, which will help to offset the cost of the credit hour. International students who have no work permit need to be aware of this requirement and cost. The MEng program committee will work towards a sponsored program in the future to offset the cost of the internship credit. An example of an internship engagement with MSCI is enclosed in Appendix C.

> The internship course objectives are to merge program knowledge with internship goals, which may include analysis of industry dynamics, business models, market trends, and investment analytics in a single or multiple industry sector, as related to infrastructure finance. A final report will be prepared for the client who will ultimately approve the quality of the work. Inasmuch as intellectual property and client confidentiality requirements are not violated, the report will be bookmarked and catalogued. At a minimum, the student will be required to submit a report to the Program Committee with an assessment of the client on the quality of the work.

It is anticipated that after a year of corporate engagement in the MEng program, the Program Administrative committee will have a chance to define the constraints and requirements for the internship and to streamline requirements.

### L. Program Administration

Administration. The Program Administration will be directed by faculty members Peter Adriaens and Glen Daigger, Carol Menassa, SangHyun Lee, Branko Kerkez, Yafeng Yin, who will work closely with the Graduate Commitee. Professor Adriaens will lead the programmatic implementation in collaboration with the MEng Admin team. Since all but the Internship and the Engineering Economics and Finance courses are existing offerings in the Department, the College or across campus, no extra burden for the directing faculty is expected beyond student advising. Letters of support have been requested from the affected Schools and Departments, following informal agreements from the faculty (please see Appendix D)

Program Stewardship. The program will be evaluated annually during the ADGE graduate program discussion with the Department Chair in the Fall. The Program Director will first prepare a report that reviews admissions, enrollments, student completion progress, course offerings, faculty participation, and student outcomes. This report will be discussed and revised if necessary by the Program Committee and the External Advisory Team at a dedicated review meeting. The Program Director will then discuss the revised report with the Associate Dean for Graduate Education at an annual meeting. After three years and every year thereafter, an anonymous survey of students (current and graduated) and faculty involved in the program will be conducted to solicit feedback and assess program format and participant satisfaction.

Recruitment and Graduation Audits. Student recruitment will be conducted through the regular CEE Master's application and other on-campus degree transfer programs (e.g. Business, Law, or Policy). To facilitate attracting non-CEE students, we will adhere to Rackham's transfer of credit program policy, as warranted. Within CEE, the Graduate Committee will handle all applications, from the perspective of whether the students meet the undergraduate requirements. The MEng Program Administration faculty will be responsible for admission in the MEng Program once students are admitted for graduate study in CEE, for graduation audits, and to address curricular issues once the students are admitted.

As indicated in Section F, prospective students are counseled to review program admission requirements and prerequisite course requirements prior to considering applying to the Program. Since this is a new program, which reaches out across campus to and to the professional community, recruitment guidelines and audits will be updated as needed.

Marketing. Promotional materials will be distributed as other CEE MEng programs via e-media and social networks. We intend to target a broad audience of students across engineering, business, policy and law disciplines with an interest in the deployment of smart and sustainable infrastructure systems in developing and developed economies.

Costs. It is expected that initially the Program will be able to leverage existing recruitment and marketing infrastructure. However, once the Program is fully implemented, a recruitment and marketing/communications coordinator will be appointed, with associated HR, office and IT infrastructure costs.

### M. Faculty

Professor Peter Adriaens. Dr. Adriaens is Professor of Environmental Engineering, Finance and Entrepreneurship. His research in the Center for Digital Asset Finance focuses on digital finance, fintech, and business models for infrastructure and associated supply chains. From 2014-2016, he was Finnish Distinguished Professor at the Research Institute of the Finnish Economy, He serves as advisor to the Great Lakes Impact Investment Platform, an institutional impact investment fund, and is on the advisory board of two infrastructure firms (Integrated Roadways and Blockchain Triangle). He teaches Environmental Finance, Entrepreneurship, and Infrastructure Finance courses and is a member of the Royal Belgian Academy of Applied Science and the Arts.

Professor Glen Daigger. Dr. Daigger is Professor of Engineering Practice at the University of Michigan and President and Founder of One Water Solutions, LLC, a water engineering and innovation firm. He previously served as Senior Vice President and Chief Technology Officer for CH2M HILL where he was employed for 35 years, as well as Professor and Chair of Environmental Systems Engineering at Clemson University. Actively engaged in the water profession, and as author or co-author of more than 100 technical papers, four books, and several technical manuals, he contributes to significantly advance practice within the water profession. He is a member of the US National Academy of Engineers (NAE).

Professor Carol Menassa. Dr. Menassa is Professor & John L. Tishman Construction Management Faculty Scholar. Her research focuses on understanding and modeling the impact of occupants on energy use in buildings, and on developing cost-based decision frameworks to sustainably retrofit existing buildings. She uses energy simulation, complex adaptive systems modeling, high-level architecture and informatics, and options-based decision tools, and manages research in international construction, integrated project delivery and quantitative assessment of project manager competencies.

Professor SangHyun Lee. Dr. Lee is Associate Professor & John L. Tishman Construction Management Faculty Scholar. His work focuses on understanding and managing construction dynamics and human-infrastructure interface through sensing, data analytics and computer simulation. Particularly, he is interested in achieving the maximum benefit from technologies like wearables, automation, and robotics for humans in construction and infrastructure. He also applies these technologies to direct smart and connected communities and cities toward social equality.

Professor Branko Kerkez. Dr. Kerkez is an Assistant Professor in the Civil and Environmental Engineering department. His research interests include water, data, and sensors. He heads the Real-time Water Systems Lab, where his group is conducting fundamental research on “smart” water systems. Dr. Kerkez is the founder of Open-Storm.org, an open source consortium dedicated to freely sharing technologies and lessons for the sensing and control of water systems. He received his M.S. and Ph.D. in Civil and Environmental Engineering, and an M.S. in Electrical Engineering and Computer Science, all from UC Berkeley.

Professor Yafeng Yin. Dr. Yin is current CEE Department Chair. His interests include analysis, modeling, design and optimization of transportation systems towards achieving sustainability and economic efficiency. His ongoing research involves examining the interdependency of urban infrastructure systems and investigating the implications of emerging vehicular and information technologies on urban mobility. He is Editor-in-Chief of Transportation Research Part C: Emerging Technologies, and edits for key journals in transportation systems.

Professor Seth Guikema is appointed in the departments of Industrial & Operations Engineering and Civil and Environmental Engineering at the University of Michigan. He is also a Professor II (adjunct) in the Department of Safety, Economics, and Planning at the University of Stavanger as well as a Data Science Research Fellow at One Concern, Inc. President of the Society for Risk Analysis (SRA). He was chairperson of both the Foundations of Risk Analysis and Engineering and Infrastructure specialty groups

and is a Fellow of the Society for Risk Analysis. He currently serves as the Area Editor for the Natural Hazards area for Risk Analysis and as the Area Editor for the Mathematical Modeling area for Risk Analysis.

The core team will work closely with finance and data science experts in business, policy and law to complement expertise represented among the CEE management team. Specifically, faculty at the Michigan Institute for Data Science (MIDAS), the Center for Finance, Law and Policy (CFLP; Law/Policy), the Center for Venture Capital and Private Equity Finance (CVPE; Ross), and the Center for Value Chain Innovation (VCI; Ross) will be engaged under ad hoc agreements.

### N. Enrollment, Scheduling Plans, and Implementation

Students have registered in the program for enrollment in Fall 2020 and Fall 2021. It was anticipated that up to 10 students will enroll in the first year, but we hope to cap enrollments at 25 students when the program matures.

### O. Specialized Facilities, including External Sites as Required

External sites to be offered by the sponsoring company. Selected courses may be live-streamed or videotaped for off-site students and professional participants from industry, NGOs or multi-lateral organizations as indicated earlier.

**Non-Attendance Drop Statement Proposal**

The CoE Registrar's Office received an inquiry regarding whether a CoE professor could administratively drop a student from their engineering class section due to inactivity.

After reaching out to the Registrar's Office to inquire about this possibility, the CoE RO learned that Engineering currently does not have a statement that students will be dropped for non-attendance. LSA does currently have a non-attendance statement, which can be reviewed below.

A recent example was a project-based course (ENGR 100) in which students needed to be assigned to teams and waiting until the end of the course and giving the student an ED grade could impact the team projects.

LSA's Policy Statement:

IT IS CRITICAL THAT STUDENTS ATTEND CLASSES FROM THE BEGINNING OF THE TERM. EVEN THOUGH STUDENTS MAY BE REGISTERED OFFICIALLY FOR A COURSE, DEPARTMENTS MAY GIVE AWAY A STUDENT'S PLACE IN A CLASS IF THEY DO NOT ATTEND:

---THE FIRST MEETING OF BIOLOGY, CHEMISTRY, AND PHYSICS LABORATORIES;

---EITHER OF THE FIRST TWO MEETINGS OF ENGLISH COURSES;

---THE FIRST TWO MEETINGS OF HISTORY 496 AND 497;

---EITHER OF THE FIRST TWO MEETINGS OF ANY COURSE OFFERED BY THE DEPARTMENT OF ROMANCE LANGUAGES;

---THE FIRST TWO MEETINGS OF COURSES IN OTHER SUBJECTS.

AT THE SAME TIME, DEPARTMENTS ARE NOT OBLIGATED TO WITHDRAW STUDENTS OFFICIALLY FROM THE COURSE, EVEN THOUGH THE STUDENT HAS BEEN INFORMED THAT HIS/HER PLACE IN A COURSE HAS BEEN TAKEN AWAY. STUDENTS ARE RESPONSIBLE FOR THE ACCURACY OF THEIR SCHEDULES AND MUST BE SURE THAT ALL DROPS ARE PROCESSED THROUGH REGISTRATION SYSTEM DURING THE NORMAL DROP/ADD PERIOD.

The CoE RO is bringing this information forward to the CoE Curriculum Committee to decide on a path forward. A non-exhaustive list of a few identified options are as follows:

1. Adopt the same (or similar) non-attendance statement and procedure as LSA, which would allow the unit's curriculum coordinator permission to approve of and request a non-attendance class drop for a given student by reaching out to the Registrar's Office (wolverineservices@umich.edu).
2. Create a modified non-attendance statement and procedure (details would be determined by the CCC).
3. Do not allow departments or units to administratively drop students from classes on the basis of non-attendance.

# Review of Professional or Creative Development Courses (PCDC) Degree Audit Rules

CoE Bulletin Language:

**Intellectual Breadth**

It is important that our students learn about modes of thought and areas of human accomplishment beyond the purely technical. This breadth can be designed by students to provide context to their engineering work by learning about human modes of thought, the structure and history of the human societies that they serve as engineers, how humans behave and interact, and how humans express their aspirations in the arts, literature and music. This breadth will help students to understand the impact of engineering solutions in a global, economic, environmental and societal context. This breadth makes our students more flexible, creative and better able to work with diverse groups.

We cannot precisely define all of these possibilities for every student so we strive to create a broad intellectual opportunity for students to pursue their interests both beyond and within engineering. Students are encouraged to use these credits in a coherent way to build a foundation of understanding in both the liberal arts and other disciplines that might contribute to their development of creativity or professional foundation.

The College of Engineering requires all students to complete 16 credits of Intellectual Breadth coursework, and between 9 and 16 credits of General Electives (depending on engineering major). To satisfy the Intellectual Breadth requirement, students must complete the following:

- **16 Intellectual Breadth Credits:** Comprised of Liberal Arts Courses (LACs — defined in the following section of the Bulletin titled, "Definition of Liberal Arts Courses"), including:
    - **Humanities:** At least 3 credits of Humanities classes marked HU in the LSA course guide, credit by test cannot be used to meet this requirement
    - **300-level LAC:** At least 3 credits of LAC must be at the 300 level or higher. Students *may* satisfy the Humanities and 300-level requirements with a single course.
    - **(Optional) PCDC** – no more than 4 credits of PCDC (defined in the following section of the Bulletin titled, "Professional or Creative Development Courses"

**Professional or Creative Development Courses (PCDC)**

Professional and creative development courses are optional and offer a student the opportunity to build on non-engineering and non-technical courses to develop their creativity and professional capabilities as engineers. PCDC courses include any course from the following subjects in the indicated units, provided they are not marked BS (Bachelor of Science) or NS (Natural Science) in the LSA course guide:

- Taubman College of Architecture and Urban Planning: Architecture (ARCH), Urban Design (UD), Urban Planning (UP), Urban and Regional Planning (URP—Effective FA 17)
- Stamps School of Art & Design (ARTDES, UARTS)

- Ross School of Business: Accounting (ACC), Business Administration (BA), Business Economics and Public Policy (BE), Entrepreneurial Studies (ES), Business Law & Business Communication (BL&BCOM), Marketing (MKT), Management and Organization (MO), Strategy (STRATEGY)
- School of Music, Theatre & Dance: Music Composition (COMP), Musicology (MUSICOL), Music Theory (THEORY), Theater & Drama (THTREMUS) and MUSPERF 300/PAT 305 (this course is an exception, no other PAT/MUSPERF courses will satisfy PCDC requirement)
- School of Environment and Sustainability (EAS)
- Ford School of Public Policy (PUBPOL)
- School of Public Health: Health Behavior & Health Education (HBEHED), Health Management & Policy (HMP)
- College of Engineering: Center for Entrepreneurship (ENTR) – Effective WN 2018 (ENTR coursework taken FA 2013 and later can be used to satisfy PCDC requirements)

**As an example, ARCH 215 has the HU course attribute and is also PCDC. How should this course be treated?**

Here is a scenario. Let's say a student has:

- PUBPOL 200. 4 credits, FA22 (PUBPOL is on the PCDC list)
- ARCH 215. 4 credits, FA23 (ARCH is on the PCDC list, and ARCH 215 counts as HU)

Having PUBPOL 200, the student has reached the limit of 4 PCDC credits that can count toward 16 IB credits.
What should happen in the audit when the student takes ARCH 215? There are 3 options:

1. ARCH 215 should not count toward the 3 credits of Humanities requirement, and should not count toward 16 IB credits.
2. ARCH 215 should count toward the 3 credits of Humanities, but should NOT count toward the total 16 IB credits. (The student will need 3 credits of something else to count toward the 16 IB credit total.)
3. ARCH 215 should count toward BOTH 3 credits of Humanities AND toward the 16 IB credits - even though the 4 credits max had been met with PUBPOL 200. (Basically, the HU designation negates the PCDC designation.)

The current understanding of the rule is #3, should we continue this, or follow the old rule that says HU courses should not be allowed in PCDC.

Susan Montgomery's take on this, "Strange. I imagine maybe there was confusion about whether a course that was both PCDC and HU should go into the PCDC slot or the HU slot, and someone wanted to make sure that it went into the HU slot? If that's not the case, better to have the audit match the bulletin, particularly when it opens up potentially more options for our students." So, if it is possible to prioritize a HU category course to go to the HU slot first, that would be preferable. If that is done, then the PCDC course could have the HU category associated with it.

# 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: 2023-03-30
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☐ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Civil & Environmental Engin<br>Subject: CEE<br>Catalog: 211 | Dept (Home): Civil & Environmental Engin<br>Subject: CEE<br>Catalog: 211 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>Statics & Dynamics | Course Title (full title)<br>Statics & Dynamics |
| ☐ | Abbreviated Title (20 char)<br>Statics&Dynamics | Abbreviated Title (20 char)<br>Statics&Dynamics |
| ☑ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Statics: review of vector mathematics; moment and force resultants; static equilibrium in two & three dimensions; centroids; center of gravity; distributed loadings; mass and area moments of inertia and principal directions. Dynamics: review of concepts of velocity and acceleration; dynamics of particles and rigid bodies; concepts of work, energy, momentum. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 4 Graduate Min:<br>Undergraduate Max: 4 Graduate Max: | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Civil & Environmental Engin  Catalog: 211

☐

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)<br>Physics 140 | Advisory Prerequisite (254 char)<br>Physics 140 |
| ☐ | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☐ | Credit Exclusions | Credit Exclusions |

☐

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

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

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

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

Contact Person: Matt Blank  Email: blankm@umich.edu  Phone: 734.764.8405

CoE Curriculum Committee Representative: Roman D. Hryciw  Print: ROMAN D. HRYCIW  Date: 8/8/23

CoE Curriculum Committee Chair:  Print:  Date:

Home Department Chair:  Print: Yafeng Yin  Date: 8/8/23

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair:  Print:  Date:

**DEPARTMENTAL/COLLEGE USE ONLY**

| Current: | Requested: |
|---|---|
| Course Description<br>Statics: review of vector mathematics; moment and force resultants; static equilibrium in two & three dimensions; centroids; center of gravity; distributed loadings.<br>Dynamics: review of concepts of velocity and acceleration; dynamics of particles and rigid bodies; concepts of work, energy, momentum; introduction to vibrations. Four lectures per week. | Course Description<br>Statics: review of vector mathematics; moment and force resultants; static equilibrium in two & three dimensions; centroids; center of gravity; distributed loadings; mass and area moments of inertia and principal directions.<br>Dynamics: review of concepts of velocity and acceleration; dynamics of particles and rigid bodies; concepts of work, energy, momentum. |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture):<br>4 | Contact hours (lecture):<br>4 |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab) | Contact hours (lab) |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Required course for all students in BSE Civil Engineering and BSE Environmental Engineering.

Special resources of facilities required for this course:

Supporting statement:
The requested change is meant to more accurately reflect the content of the course. The concepts of "mass and area moments of inertia and principal directions" have been added, as these are fundamental to following courses and specifically to the material taught in CEE 212: Solid and Structural Mechanics; "introduction to vibrations", which is not typically included in the syllabus, has been removed.

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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: 2023-08-22
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☑ | Dept (Home):<br>Subject:<br>Catalog: | Dept (Home): Civil & Environmental Engin<br>Subject: CEE<br>Catalog: 503 |
| ☐ | ☐ Course is Cross-Listed with Other Departments | ☐ Course is Cross-Listed with Other Departments |
| | Department / Subject / Catalog Number | Department / Subject / Catalog Number |
| ☑ | Course Title (full title) | Course Title (full title)<br>Infrastructure Project Finance |
| ☑ | Abbreviated Title (20 char) | Abbreviated Title (20 char)<br>Infras Proj Finance |
| ☑ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Project financing and public-private partnerships are used to finance public and private infrastructure assets. These models are increasingly disrupted by infrastructure digitalization and data monetization. This course reviews financing models and contracting mechanisms across infrastructure use cases and employs a term project focused on smart infrastructure systems. | |
| ☑ | Full Term Credit Hours<br>Undergraduate Min: Graduate Min: 3<br>Undergraduate Max: Graduate Max: 3 | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☑ | Course Credit Type<br>Rackham Graduate Student, Non-Rackham Graduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Catalog:

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

| | CURRENT LISTING | REQUESTED LISTING |
|---|---|---|
| ☑ | Advisory Prerequisite (254 char) | Advisory Prerequisite (254 char)<br>CEE 504 |
| ☐ | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☐ | Credit Exclusions | Credit Exclusions |

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

Cognizant Faculty Member Name: Peter Adriaens Cognizant Faculty Member Title: Professor

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

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

CoE Curriculum Committee Representative: Roman D. Haycin Print: ROMAN D. HAYCIN Date: 8/8/23

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair: Print: Yafeng Yin Date: 8/8/23

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

**DEPARTMENTAL/COLLEGE USE ONLY**

| Current: | Requested: |
|---|---|
| Course Description | Course Description<br>Project financing and public-private partnerships are used to finance public and private infrastructure assets. These models are increasingly disrupted by infrastructure digitalization and data monetization. This course reviews financing models and contracting mechanisms across infrastructure use cases and employs a term project focused on smart infrastructure systems. |
| Class Length | Class Length<br>Full term |
| Contact hours (lecture): | Contact hours (lecture):<br>3 |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab) | Contact hours (lab) |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
This is a core course of the MEng program in Smart Infrastructure Finance.

Special resources of facilities required for this course:

Supporting statement:
The role of engineers in society is changing. In the past, engineers tended to have a focus on the technical aspects of a problem, and on strictly computational aspects of engineering economics such as net present value and discounted cash flows to decide on whether to proceed with a project. Today, engineers are more likely to become the decision makers, and they need to be able to take into account strategic and policy issues, as well as the changing technological and finance environment in which decisions are made.

Smart infrastructure finance is a major change in this environment because the business models of infrastructure and projects in the Internet of Things (IoT) economy are shifting towards data monetization and financial technology to execute on smart contracts. This is starting to change how infrastructure projects are financed, and how decisions are made whether and how to move forward with a project. With CEE faculty in the vanguard of intelligent systems and automation, this course seeks to educate students in the ways financial decisions will be influenced by the business models behind smart infrastructure.

The course has been taught 4 times, once before initiation of the SIF MEng Program, two times during the offering of the SIF MEng, and once during suspension and reset of the SIF MEng: Fall 2019 (the course was still called CEE 504: enrollment: 9), Winter 2021 (offered as CEE 501.004; enrollment: 11 ), Fall 2021 (CEE 501.004; enrollment: 12), and Winter 2023 (CEE 501.004: enrollment: 5 - after the MEng was deferred for the current reset). I have been asked and

started discussions with the School for Public Policy and the Law School for future cross-listing of this course with the Master of Public Policy (MPP) and Master of Public Accounting (MPA) programs, to be finalized in AV 2023-24.

# CEE 501 004 WN 2023



Jump to Today ✎ Edit

# *INFRASTRUCTURE PROJECT FINANCE*

**Description**

Over the past year, the Biden-Harris Administration delivered on the 2021 **Bipartisan Infrastructure Law** (https://www.whitehouse.gov/bipartisan-infrastructure-law/) and the **2022 Inflation Reduction Act** (https://www.progressivecaucuscenter.org/whats-in-the-final-text-of-the-inflation-reduction-act) to invest invest in sustainable and critical infrastructure, from renewable energy to resilient water and stormwater systems, from upgrades to smart and autonomous road infrastructure to schools and broadband. **These Law and Act represent the largest investment in US infrastructure since the Eisenhower Administration**.

There is a $2 trn infrastructure finance gap in the US, yet annually there is $5.4 trn infrastructure financing available globally that does not get invested because of mismatching problems between risk and return expectations and project designs. The problem with infrastructure has never been a lack of money, the challenge is a lack of public funding to pay for the financing of these systems. New public-private partnerships (P3) and smart infrastructure are argued to become part of the solution, but how do they work? How does digital financing (e.g. blockchain) of infrastructure fit in the mix? Infrastructure innovation requires financial innovation. This course will provide an overview on the financing of infrastructure with focus on project finance in the context of public private partnerships, with ample illustrations of use cases in the practice.

**Course Modules**

1. *The Innovation Opportunity. Infrastructure as a Sustainable Asset Class.* This module will describe the current state of public infrastructure financing and public-private partnerships, how infrastructure evolved into becoming an investable entity and how sustainability considerations data are starting to disrupt the financial models and economics of infrastructure systems.
2. *Setting a Benchmark. Infrastructure System Characterization and Finance.* This module focuses on the evolving definition of how investors view infrastructure as a real and digital asset, how this influences the classification of different infrastructures and operational models in the context of a risk and return framework, and what the implications are for financing (public, private, crowd, and P3 models).
3. *Risk Framework. Impact on Investment Decisions.* This module addresses uncertainties and key operational risks of projects, including capital risk, asset liability, privacy and cybersecurity, taxes and inflation. Risk factors influence investment decisions, affect which actors in the investment ecosystem become involved, and the financial return expectations of the investor.
4. *Digitization & Data Markets. A. Data Structure and Classification.* This module focuses on how data have become 'digital twins' of the infrastructure system, as they allow to query operations, intangible value and derivative value beyond the physical asset. We tend to think about infrastructure in silos (energy, water, waste, roads) because of the real asset perspective.
5. *Digitization & Data Markets. B. Information Valuation and Pricing.* The value of information from smart infrastructure can potentially be captured as yield (interest), equity value (internal rate of return), via auctions in the data markets, or to hedge/reduce tax, inflation, or insurance impacts in infrastructure design and operations.
6. *Capturing Informational Value. Data-Driven Business Models, Efficient Financing and the Emerging Prosumer.* This module covers financing approaches for (smart) infrastructure, and explore how data influence fixed income (bonds, debt), public (infrastructure funds and REITs) and private equity (non-listed investments), project finance models, public private partnerships (P3), risk transfer instruments and digital finance (blockchain tokens).
7. *Design Implications: Design for Investability.* Bringing it back to engineering design, the prior modules illustrate how finance can be treated as a design constraint (boundary condition). Design and functionality affect how road, water, waste and energy systems are financed and vice versa.

**Objectives:**

1. Become comfortable with various forms of infrastructure project finance
2. Be exposed to a wide range of financial structures (bonds, private equity, debt, REITs, etc) that are used in infrastructure projects
3. Understand the cash flow requirements and risk allocation strategies for project investment under public-private partnerships (P3) and private investment
4. Explore the impact of data for financing of demand-driven infrastructure systems
5. Integrate project finance structures and data in innovative new business models for infra operation

**W 2023 – Hybrid Learning Model**

**Location: 1025 G.G. Brown Building**, North Campus)

**MW noon-1:30 p.m.**

**Office Hours:** MW after class. via Zoom, in-person by appointment; other meetings by request

**Instructor:** Peter Adriaens, PhD, P.E. **adriaens@umich.edu** (mailto:adriaens@umich.edu)

Dr. Adriaens is Professor of Environmental Engineering, Finance and Entrepreneurship, and Professor in the School for Environment and Sustainability (SEAS). He was previously Professor of Entrepreneurship at the Ross School of Business (2006-2016). He directs the **Center on Digital Asset Finance** (https://www.difin.io/) and is Program Director of the new **MEng in Smart Infrastructure Finance** (https://masters.engin.umich.edu/degree/smart-infrastructure-finance-meng/) . He is past-President of the Association of Environmental Science and Engineering Professors (AEESP), a member-by-eminence of the American Academy of Environmental Engineering (AAEE), as well as a Member of the Belgian Royal Academy of Applied Sciences. He has held distinguished Professorship appointments in China (Suzhou) and Europe (Finland), and is co-founder/CEO of **Equarius Risk Analytics** (http://www.equariusrisk.com) , a financial technology company focused on water-based equity risk pricing and corporate risk management.

**Text:** There is no textbook on this topic, but chapters and sections from Stefano Gatti (2019). **Project Finance in Theory and Practice** (https://www-sciencedirect-com.proxy.lib.umich.edu/book/9780128114018/project-finance-in-theory-and-practice) as well as Weber et al. (2016) **Infrastructure as an Asset Class** (https://onlinelibrary.wiley.com/doi/book/10.1002/9781119226574) will be used.

**Course Pack**. In addition to the text readings, we will will discuss infrastructure and project finance cases from Harvard Business School, available for purchase at following link: **https://hbsp.harvard.edu/import/1013312** (https://hbsp.harvard.edu/import/1013312) .

**Evaluation:**

The grading structure involves both a paper and in class participation (this will be augmented with discussion activities on Canvas):

1. Project paper: 50%
2. In class participation (demonstrate you have read the assigned materials): 30%
3. Homework assignments: 20% (the HW are cumulative and make up the paper structure)

In addition, in class or on-line quizzes/questions will be posted to check engagement and participation. Whereas these checks will not be explicitly graded, the statistics compiled by Canvas will be used to help inform your participation grade.

**Engagement:**

Lectures will be generally given in person at the posted class time, but pre-recorded sessions (Zoom) may be posted a few days before the lecture. Typically, Monday lectures tend to be content-driven and Wednesday lectures focus on a use case or business case. Each in-person lecture and all discussion session will be simultaneously recorded in the course Canvas archive for asynchronous viewing. During the lectures and discussion sessions, students are expected to turn on their camera when Zoom meetings are organized. Exceptions are made for students who cannot attend because of timezone limitations or other excused absences. Instructor office hours will be conducted weekly on-line using both Zoom or by appointment. Questions regarding any topic can be posted at any time on-line to facilitate rapid responses. It's my personal goal this semester to be as available to students as if it were a normal semester.

The course relies on a team-based class project to assess knowledge and independent research. Student teams will be formed early in the course and teams will be expected to engage and check in on a regular basis. Unless otherwise agreed, office hours will be held on Zoom, and emphasize Q&A related to the project.

**Class Schedule**

| Module | F 2021 | Topic | Assignments |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Week 1** | 01/04 | ***Introduction to class***<br>What is infrastructure?<br>What is smart infrastructure?<br>**Video** (https://www.youtube.com/watch?v=gjh6-ZF2n3Y) : CEE Smart Infrastructure Finance | **Bipartisan Infrastructure Law** (https://www.whitehouse.gov/bipartisan-infrastructure-law/#:~:text=The%20legislation%20invests%20%2417%20billion,and%20other%20low%2Dcarbo 2021 (White House)<br>Adriaens **BloombergCitiLab OpEd** (https://www.bloomberg.com/news/articles/2021-04-07/pay-for-infrastructure) (The Hill) |
| **Week 2** | 01/09 | ***I***nfrastructure overview:<br>Project, assets and facilities<br>Infrastructure companies<br>Role of the private sector<br>Definitions and characteristics of infrastructure | Weber Chapter 1. Infrastructure – An overview |
| | 01/11 | ***Infrastructure as an asset class: Private investor decision-making***<br>Risk and return profiles of infrastructure<br>Yield-driven vs IRR-driven investors<br>Greenfield and Brownfield<br>Sustainability considerations | Weber Chapter 2. 2.1. Infrastructure as an asset class |
| **Week 3 (Prof A in Japan)** | 01/16 | Martin Luther King Day - No Class | |
| | 01/18 | ***Funding and Financing Instruments (will be prerecorded - follow up after return)***<br>Debt, equity, bonds, asset backed securities, government (will focus on US, not EU schemes); Impacts on return expectations (IRR, ROI) | Weber Chapter 7. Financing instruments<br>HBS Case: Finding the Money. An Overview of Infrastructure Finance Challenges and Oppo |
| **Week 4** | 01/23 | ***Application of Financing Instruments: California High Speed Rail*** | HBS: Gomez-Ibanez (2011) California High Speed Rail |
| | 01/25 | ***Organizational Models of Infrastructure Implementation***<br>Privatization models; Partnership models; Business models; Contractual models | Weber Chapter 3.<br>Organizational models (focus on P3) |
| **Week 5** | 01/30 | ***Organizational Models of Infrastructure Implementation, cont.***<br>Public, private and public-private partnerships (PPP): Business and financing models | Poseidon Carlsbad: Desalination and the San Diego County Water Authority (HBS) |
| | 02/01 | ***Introduction to Project Finance***<br>Basics of project finance; Applications in traditional and P3 models; Terminology; Difference from Corporate Finance; Complexity | Gatti, Chapter 1<br>Introduction to Project Finance |
| **Week 6** | 02/06 | **Project Characteristics, Risk Analysis, Risk Management**<br>Project Risks | Gatti, Chapter 3. |
| | 02/08 | ***External Lecturer:*** | |

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|---|---|---|---|
| | | Digitizing infrastructure project agreements (Giridhar Srinivasan, CEO and Founder, InfraClear (https://www.infraclear.com/) )<br><br>instead:<br><br>Discussion of Cheniere through the lens of systematic and non-systematic (project) financial risk management | |
| **Week 7** | 02/13 | First check in: Deliverable 1 | Rubric (%24CANVAS_COURSE_REFERENCE%24/file_ref/g851a0b924b4b743e4e99f4fbba41afdl |
| | | ***Project Finance Application in P3 Models*** | |
| | 02/15 | *Follow up commentary: https://www.governing.com/topics/mgmt/indiana-toll-road-model-privatization.html https://usa.streetsblog.org/2014/11/18/the-indiana-toll-road-and-the-dark-side-of-privately-financed-highways/* | HBS: Public-Private Partnerships: The Project Financing of the Indiana Toll Road |
| | | ***Project Valuation and Cash Flow Analysis*** | |
| **Week 8** | 02/20 | Operating cash flows and capital structure<br><br>Follow up on Heathrow | Gatti, Chapter 5 |
| | 02/22 | Cash flows, ROI, IRR calculations (Heathrow slides, video and spreadsheet model) | Handouts |
| | | **Winter Break (02/25-03/05)** | |
| | | ***Project Valuation and Cash Flow Analysis*** | |
| **Week 9** | 03/06 | Capital structure, cover ratios and scenario analysis<br><br>Follow up on Heathrow | Gatti, Chapter 5 |
| | 03/08 | ***External Lecturer: Raymond A. DiPrinzio Managing Director, Global Sponsor Coverage and Co-Head of Infrastructure Finance, Sumitomi Mitsui Banking Corporation***<br><br>Project Finance & Public Private Partnerships: An investment banking perspective | TBA |
| | | ***Financing/closing the Deal*** | |
| **Week 10** | 03/13 | Activities, fee structure, financing options | Gatti. Chapter 6 |

| | | | |
|---|---|---|---|
| | 03/15 | Second check in: Report out 2 | |
| **Week 11** | 03/20 | ***Smart Infrastructure Finance Introduction***<br>What is smart infrastructure? What is smart financing? What is digital finance? | Industry 4.0 and the Sustainable Built Environment: Smart Infrastructure Finance (video (http://Industry%204.0%20and%20the%20Sustainable%20Built%20Environment:%20Smart%20I )<br>Read: Prosumer blog (LinkedIn (https://www.linkedin.com/pulse/rebuilding-our-relationshi peter-adriaens/?trackingId=%2BuEgdd3lThq1rBlSy3rd%2Fw%3D%3D) ) |
| | 03/22 | ***Smart Infrastructure***<br>Understanding data streams, bond financing, revenue securitization ABS-P3 models (asset backed security-public-private partnership) --> 03/27 | Dallas Cowboys: Financing a New Stadium (HBS) (https://umich.instructure.com/courses/ wrap=1) (https://umich.instructure.com/courses/588415/files/28817784/download?download |
| **Week 12** | 03/27 | ***Digital infrastructure: Securitization Cont'***<br>Asset-backed securities for infrastructure financing --> 03/29 | Adriaens and Gupta - KAIA paper (https://umich.instructure.com/courses/588415/files/302345 (https://umich.instructure.com/courses/588415/files/30234528/download?download_frd=1) on di<br>Gatti. Case Study 5. Viveraqua Hydrobond (https://umich.instructure.com/courses/588415/ (https://umich.instructure.com/courses/588415/files/28817814/download?download_frd=1) |
| | 03/29 | ***Information valuation and pricing***<br>Implications of data on cash flow analysis and risk pricing<br>--> 04/03 | (https://umich.instructure.com/courses/391813/files/15664236/download?wrap=1)<br>Wolfberg and Adriaens: White paper and presentation to COP26/27 (see in linked ref)<br>https://www.triangle.digital/resources (https://www.triangle.digital/resources)<br>Muschalle (2013): Pricing approaches for data markets (Canvas) (https://umich.instructure.com/courses/588415/files/28817778?wrap=1) (https://umich.instructure.com/courses/588415/files/28817778/download?download_frd=1) |
| **Week 13** | 04/03 | **External Speaker (Tim Sylvester, CEO, Integrated Roadways (https://integratedroadways.com/) ).** Role of smart pavement to enable smart roads. | |
| | 04/05 | ***Technology-Enabled Financing of Infrastructure***<br>What is blockchain?<br>Benefits of tokenization?<br>Smart contracts and cost of capital? | Uzsoki (2019) (https://umich.instructure.com/courses/588415/files/28817786?wrap=1) (https://umich.instructure.com/courses/588415/files/28817786/download?download_frd=1) . Tok Infrastructure. A Blockchain Solution for Sustainable Infrastructure (Canvas) |
| **Week 14** | 04/10 | ***Tokenized OPEX Financing***<br>*Use case: Brooklyn transactive grid for residential solar energy deployment* | Mengelkamp et al. (2018) (https://umich.instructure.com/courses/588415/files/28817848?wra (https://umich.instructure.com/courses/588415/files/28817848/download?download_frd=1) . De energy markets. A case study: The Brooklyn Microgrid. Applied Energy 210 (2018) 870–880 |
| | 04/12 | ***No class (Adriaens at Bermuda Tech Conference):*** | View Adriaens interview with Nuveen, Citi, and Blockchain Triangle on YouTube (https://w v=NP-dhFQ0Bfs&t=477s) |

| | | | |
|---|---|---|---|
| **Week 15** | 04/17 | ***Designing and financing smart city infrastructure***<br>Impact of data and digital financing models on cost of capital and cash flows in infrastructure projects?<br><br>Third Check in: Deliverable 3 | HBS Case: Smart Cities via Public-Private Partnerships<br><br>**Deloitte Smart Cities Financing (Canvas) (https://umich.instructure.com/courses/588415/file (https://umich.instructure.com/courses/588415/files/28817847/download?download_frd=1)** |

# Course Summary:

| Date | Details | Due |
|---|---|---|
| Wed Jan 4, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633168&include_contexts=course_588415) | 12pm to 1:30pm |
| Mon Jan 9, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633169&include_contexts=course_588415) | 12pm to 1:30pm |
| Wed Jan 11, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633170&include_contexts=course_588415) | 12pm to 1:30pm |
| Mon Jan 16, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633171&include_contexts=course_588415) | 12pm to 1:30pm |
| Wed Jan 18, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633172&include_contexts=course_588415) | 12pm to 1:30pm |
| Mon Jan 23, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633173&include_contexts=course_588415) | 12pm to 1:30pm |
| Wed Jan 25, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633174&include_contexts=course_588415) | 12pm to 1:30pm |
| Mon Jan 30, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633175&include_contexts=course_588415) | 12pm to 1:30pm |
| Wed Feb 1, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633176&include_contexts=course_588415) | 12pm to 1:30pm |
| Mon Feb 6, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633177&include_contexts=course_588415) | 12pm to 1:30pm |
| Wed Feb 8, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633178&include_contexts=course_588415) | 12pm to 1:30pm |
| Mon Feb 13, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633179&include_contexts=course_588415) | 12pm to 1:30pm |
| | Assignment 1 - Infrastructure Project Finance (https://umich.instructure.com/courses/588415/assignments/1983032) | due by 11:59pm |
| Wed Feb 15, 2023 | CEE 501 004 WN 2023 (https://umich.instructure.com/calendar?event_id=1633180&include_contexts=course_588415) | 12pm to 1:30pm |

# University of Michigan
# Fall 2021 Instructor Report With Comments
# CEE 501 004 - CEE 501 104
# Peter Adriaens

5 out of 11 students responded to this evaluation.

**Responses to University-wide questions about the course:**

| | SA | A | N | D | SD | N/A | Your Median | Univ-wide Median | School/College Median |
|---|---|---|---|---|---|---|---|---|---|
| This course advanced my understanding of the subject matter. (Q1631) | 1 | 4 | 0 | 0 | 0 | 0 | 4.1 | 4.5 | 4.7 |
| My interest in the subject has increased because of this course. (Q1632) | 2 | 2 | 0 | 0 | 1 | 0 | 4.3 | 4.2 | 4.5 |
| I knew what was expected of me in this course.(Q1633) | 2 | 1 | 0 | 1 | 1 | 0 | 4.0 | 4.5 | 4.6 |
| I had a strong desire to take this course.(Q4) | 4 | 1 | 0 | 0 | 0 | 0 | 4.9 | 4.0 | 4.5 |
| As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891) | 2 | 2 | 1 | 0 | 0 | 0 | 4.3 | 3.0 | 3.0 |

**Responses to University-wide questions about the instructor:**

| | SA | A | N | D | SD | N/A | Your Median | Univ-wide Median | School/College Median |
|---|---|---|---|---|---|---|---|---|---|
| Peter Adriaens seemed well prepared for class meetings.(Q230) | 2 | 1 | 1 | 1 | 0 | 0 | 4.0 | 4.8 | 4.8 |
| Peter Adriaens explained material clearly.(Q199) | 2 | 1 | 1 | 1 | 0 | 0 | 4.0 | 4.7 | 4.7 |
| Peter Adriaens treated students with respect.(Q217) | 2 | 2 | 1 | 0 | 0 | 0 | 4.3 | 4.9 | 4.9 |

## Responses to questions about the course:

| | SA | A | N | D | SD | N/A | Your Median |
|---|---|---|---|---|---|---|---|
| Overall, this was an excellent course. (Q1) | 1 | 2 | 1 | 0 | 1 | 0 | 3.8 |
| I increased my ability to apply math and science knowledge to engineering problems. (Q15) | 1 | 1 | 0 | 1 | 0 | 2 | 4.0 |
| I increased my ability to analyze and interpret data. (Q17) | 1 | 1 | 0 | 1 | 0 | 2 | 4.0 |
| My confidence in my design abilities increased because of this course. (Q20) | 1 | 1 | 0 | 1 | 0 | 2 | 4.0 |
| I gained valuable experience working in teams in this course. (Q21) | 1 | 2 | 2 | 0 | 0 | 0 | 3.8 |
| I increased my ability to formulate, and solve engineering problems. (Q23) | 1 | 1 | 0 | 2 | 0 | 1 | 3.0 |
| I developed a greater understanding of my responsibilities as a professional. (Q25) | 1 | 3 | 0 | 1 | 0 | 0 | 4.0 |
| This course improved my ability to communicate technical information, designs, and analyses. (Q28) | 1 | 1 | 0 | 1 | 0 | 2 | 4.0 |
| I developed a greater understanding of the impact of engineering on the environment. (Q30) | 1 | 2 | 0 | 1 | 0 | 1 | 4.0 |
| This course increased my desire to learn more about this subject in the future. (Q32) | 2 | 2 | 0 | 0 | 1 | 0 | 4.3 |
| I have a greater understanding of how course concepts apply to contemporary problems. (Q34) | 3 | 2 | 0 | 0 | 0 | 0 | 4.7 |
| I increased my ability to apply engineering tools and methods. (Q35) | 1 | 1 | 0 | 1 | 0 | 2 | 4.0 |
| I gained a good understanding of concepts/principles in this field. (Q121) | 2 | 2 | 1 | 0 | 0 | 0 | 4.3 |
| I developed the ability to solve real problems in this field. (Q125) | 2 | 3 | 0 | 0 | 0 | 0 | 4.3 |
| Work requirements and grading system were clear from the beginning. (Q232) | 2 | 1 | 0 | 1 | 1 | 0 | 4.0 |
| The amount of work required was appropriate for the credit received. (Q239) | 2 | 1 | 1 | 0 | 1 | 0 | 4.0 |
| Examinations covered the important aspects of the course. (Q356) | 2 | 1 | 0 | 0 | 0 | 2 | 4.8 |
| Exams were reasonable in length and difficulty. (Q360) | 1 | 2 | 0 | 0 | 0 | 2 | 4.3 |
| The grading system was clearly explained. (Q366) | 2 | 2 | 0 | 1 | 0 | 0 | 4.3 |

## Responses to questions about the instructor:

| | SA | A | N | D | SD | N/A | Your Median |
|---|---|---|---|---|---|---|---|
| Overall, Peter Adriaens was an excellent teacher. (Q2) | 2 | 1 | 1 | 0 | 1 | 0 | 4.0 |
| Peter Adriaens gave clear explanations. (Q201) | 2 | 1 | 1 | 1 | 0 | 0 | 4.0 |
| Peter Adriaens stressed important points in lectures/discussions. (Q203) | 2 | 2 | 0 | 1 | 0 | 0 | 4.3 |
| Peter Adriaens appeared to have a thorough knowledge of the subject. (Q207) | 3 | 2 | 0 | 0 | 0 | 0 | 4.7 |
| Peter Adriaens acknowledged all questions insofar as possible. (Q216) | 4 | 1 | 0 | 0 | 0 | 0 | 4.9 |
| Peter Adriaens used class time well. (Q229) | 2 | 1 | 0 | 1 | 1 | 0 | 4.0 |

The medians are calculated from Fall 2021 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 1 to 15 in College of Engineering.

# University of Michigan
# Fall 2019 Instructor Report With Comments
# CEE 504-001: Engr Econ & Finance
# Peter Adriaens

4 out of 8 students responded to this evaluation.

**Responses to the University-wide questions about the course:**

| | SA | A | N | D | SD | N/A | Your Median | University-Wide Median | School/College Median |
|---|---|---|---|---|---|---|---|---|---|
| This course advanced my understanding of the subject matter. (Q1631) | 2 | 1 | 1 | 0 | 0 | 0 | 4.5 | 4.5 | 4.7 |
| My interest in the subject has increased because of this course. (Q1632) | 2 | 1 | 1 | 0 | 0 | 0 | 4.5 | 4.2 | 4.5 |
| I knew what was expected of me in this course.(Q1633) | 0 | 3 | 1 | 0 | 0 | 0 | 3.8 | 4.4 | 4.5 |
| Overall, this was an excellent course.(Q1) | 0 | 2 | 2 | 0 | 0 | 0 | 3.5 | 4.2 | 4.5 |
| I had a strong desire to take this course.(Q4) | 2 | 1 | 1 | 0 | 0 | 0 | 4.5 | 4.0 | 4.5 |
| As compared with other courses of equal credit, the workload for this course was...(SA=Much Lighter to SD=Much Heavier) (Q891) | 0 | 1 | 3 | 0 | 0 | 0 | 3.2 | 3.0 | 3.0 |

**Responses to University-wide questions about the instructor:**

| | SA | A | N | D | SD | N/A | Your Median | University-Wide Median | School/College Median |
|---|---|---|---|---|---|---|---|---|---|
| Overall, Peter Adriaens was an excellent teacher.(Q2) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.6 | 4.6 |
| Peter Adriaens seemed well prepared for class meetings.(Q230) | 1 | 3 | 0 | 0 | 0 | 0 | 4.2 | 4.8 | 4.8 |
| Peter Adriaens explained material clearly.(Q199) | 0 | 3 | 1 | 0 | 0 | 0 | 3.8 | 4.6 | 4.6 |
| Peter Adriaens treated students with respect.(Q217) | 2 | 2 | 0 | 0 | 0 | 0 | 4.5 | 4.8 | 4.9 |

### Responses to additional questions about the course:

| | SA | A | N | D | SD | N/A | Your Median | University-Wide Median |
|---|---|---|---|---|---|---|---|---|
| I increased my ability to apply math and science knowledge to engineering problems. (Q15) | 0 | 3 | 1 | 0 | 0 | 0 | 3.8 | 4.3 |
| I increased my ability to analyze and interpret data. (Q17) | 0 | 3 | 1 | 0 | 0 | 0 | 3.8 | 4.3 |
| My confidence in my design abilities increased because of this course. (Q20) | 1 | 2 | 0 | 1 | 0 | 0 | 4.0 | 4.1 |
| I gained valuable experience working in teams in this course. (Q21) | 0 | 2 | 2 | 0 | 0 | 0 | 3.5 | 4.0 |
| I increased my ability to formulate, and solve engineering problems. (Q23) | 0 | 1 | 2 | 0 | 0 | 0 | 3.3 | 4.3 |
| I developed a greater understanding of my responsibilities as a professional. (Q25) | 0 | 3 | 1 | 0 | 0 | 0 | 3.8 | 4.2 |
| This course improved my ability to communicate technical information, designs, and analyses. (Q28) | 0 | 2 | 1 | 1 | 0 | 0 | 3.5 | 4.2 |
| I developed a greater understanding of the impact of engineering on the environment. (Q30) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.4 |
| This course increased my desire to learn more about this subject in the future. (Q32) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.2 |
| I have a greater understanding of how course concepts apply to contemporary problems. (Q34) | 2 | 2 | 0 | 0 | 0 | 0 | 4.5 | 4.3 |
| I increased my ability to apply engineering tools and methods. (Q35) | 0 | 3 | 1 | 0 | 0 | 0 | 3.8 | 4.3 |
| I gained a good understanding of concepts/principles in this field. (Q121) | 0 | 3 | 1 | 0 | 0 | 0 | 3.8 | 4.3 |
| I developed the ability to solve real problems in this field. (Q125) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.3 |
| Work requirements and grading system were clear from the beginning. (Q232) | 0 | 2 | 1 | 0 | 0 | 0 | 3.8 | 4.5 |
| The amount of work required was appropriate for the credit received. (Q239) | 1 | 3 | 0 | 0 | 0 | 0 | 4.2 | 4.1 |
| Examinations covered the important aspects of the course. (Q356) | 0 | 3 | 0 | 0 | 0 | 1 | 4.0 | 4.4 |
| Exams were reasonable in length and difficulty. (Q360) | 0 | 3 | 0 | 0 | 0 | 1 | 4.0 | 4.1 |
| The grading system was clearly explained. (Q366) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.6 |

### Responses to additional questions about the instructor:

| | SA | A | N | D | SD | N/A | Your Median | University-Wide Median |
|---|---|---|---|---|---|---|---|---|
| Peter Adriaens gave clear explanations. (Q201) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.6 |
| Peter Adriaens stressed important points in lectures/discussions. (Q203) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.6 |
| Peter Adriaens appeared to have a thorough knowledge of the subject. (Q207) | 2 | 2 | 0 | 0 | 0 | 0 | 4.5 | 4.8 |
| Peter Adriaens acknowledged all questions insofar as possible. (Q216) | 2 | 2 | 0 | 0 | 0 | 0 | 4.5 | 4.7 |
| Peter Adriaens used class time well. (Q229) | 0 | 3 | 0 | 1 | 0 | 0 | 3.8 | 4.6 |

The medians are calculated from Fall 2019 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 1 to 15 in College of Engineering.

## Written Comments

### Comment on the quality of instruction in this course. (Q900)

| Comments |
|---|
| The class was less organized. |
| The course is great and the professor prepared well for the class. |

# University of Michigan
# Winter 2021 Instructor Report With Comments
# CEE 501 004 - CEE 501 104
# Peter Adriaens

4 out of 11 students responded to this evaluation.

**Responses to University-wide questions about the course:**

| | SA | A | N | D | SD | N/A | Your Median | Univ-wide Median | School/College Median |
|---|---|---|---|---|---|---|---|---|---|
| This course advanced my understanding of the subject matter. (Q1631) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.6 | 4.7 |
| My interest in the subject has increased because of this course. (Q1632) | 2 | 1 | 0 | 1 | 0 | 0 | 4.5 | 4.3 | 4.5 |
| I knew what was expected of me in this course.(Q1633) | 1 | 1 | 0 | 1 | 1 | 0 | 3.0 | 4.6 | 4.6 |
| Overall, this was an excellent course.(Q1) | 2 | 0 | 0 | 2 | 0 | 0 | 3.5 | 4.4 | 4.5 |
| I had a strong desire to take this course.(Q4) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.1 | 4.5 |
| As compared with other courses of equal credit, the workload for this course was (SA=Much Lighter, A=Lighter, N=Typical, D=Heavier, SD=Much Heavier). (Q891) | 0 | 0 | 4 | 0 | 0 | 0 | 3.0 | 2.9 | 2.9 |
| How did you participate in this course? (SA=Attended most synchronously, A=Attended most asynchronously, N=Attended most in person, D=Attended some in person and some online) (Q1854) | 4 | 0 | 0 | 0 | 0 | 0 | 5.0 | 4.8 | 4.8 |

**Responses to University-wide questions about the instructor:**

| | SA | A | N | D | SD | N/A | Your Median | Univ-wide Median | School/College Median |
|---|---|---|---|---|---|---|---|---|---|
| Overall, Peter Adriaens was an excellent teacher.(Q2) | 2 | 0 | 1 | 1 | 0 | 0 | 4.0 | 4.7 | 4.7 |
| Peter Adriaens seemed well prepared for class meetings.(Q230) | 2 | 1 | 1 | 0 | 0 | 0 | 4.5 | 4.8 | 4.8 |
| Peter Adriaens explained material clearly.(Q199) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.7 | 4.7 |
| Peter Adriaens treated students with respect.(Q217) | 3 | 0 | 1 | 0 | 0 | 0 | 4.8 | 4.9 | 4.9 |

## Responses to questions about the course:

| | SA | A | N | D | SD | N/A | Your Median | University-Wide Median |
|---|---|---|---|---|---|---|---|---|
| I increased my ability to apply math and science knowledge to engineering problems. (Q15) | 1 | 1 | 1 | 0 | 0 | 1 | 4.0 | 4.5 |
| I increased my ability to analyze and interpret data. (Q17) | 3 | 0 | 1 | 0 | 0 | 0 | 4.8 | 4.5 |
| My confidence in my design abilities increased because of this course. (Q20) | 0 | 1 | 1 | 0 | 0 | 1 | 3.5 | 4.3 |
| I gained valuable experience working in teams in this course. (Q21) | 3 | 0 | 0 | 1 | 0 | 0 | 4.8 | 4.3 |
| I increased my ability to formulate, and solve engineering problems. (Q23) | 1 | 1 | 1 | 0 | 0 | 1 | 4.0 | 4.4 |
| I developed a greater understanding of my responsibilities as a professional. (Q25) | 2 | 1 | 1 | 0 | 0 | 0 | 4.5 | 4.5 |
| This course improved my ability to communicate technical information, designs, and analyses. (Q28) | 1 | 1 | 1 | 0 | 0 | 1 | 4.0 | 4.4 |
| I developed a greater understanding of the impact of engineering on the environment. (Q30) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.4 |
| This course increased my desire to learn more about this subject in the future. (Q32) | 1 | 2 | 0 | 1 | 0 | 0 | 4.0 | 4.3 |
| I have a greater understanding of how course concepts apply to contemporary problems. (Q34) | 1 | 2 | 0 | 1 | 0 | 0 | 4.0 | 4.5 |
| I increased my ability to apply engineering tools and methods. (Q35) | 1 | 1 | 1 | 0 | 0 | 1 | 4.0 | 4.5 |
| I gained a good understanding of concepts/principles in this field. (Q121) | 1 | 3 | 0 | 0 | 0 | 0 | 4.2 | 4.5 |
| I developed the ability to solve real problems in this field. (Q125) | 1 | 2 | 1 | 0 | 0 | 0 | 4.0 | 4.5 |
| Work requirements and grading system were clear from the beginning. (Q232) | 1 | 1 | 0 | 1 | 1 | 0 | 3.0 | 4.7 |
| The amount of work required was appropriate for the credit received. (Q239) | 1 | 3 | 0 | 0 | 0 | 0 | 4.2 | 4.3 |
| Examinations covered the important aspects of the course. (Q356) | 0 | 0 | 0 | 0 | 0 | 4 | N/A | 4.5 |
| Exams were reasonable in length and difficulty. (Q360) | 0 | 0 | 0 | 0 | 0 | 4 | N/A | 4.2 |
| The grading system was clearly explained. (Q366) | 1 | 1 | 0 | 0 | 2 | 0 | 2.5 | 4.7 |

## Responses to questions about the instructor:

| | SA | A | N | D | SD | N/A | Your Median | University-Wide Median |
|---|---|---|---|---|---|---|---|---|
| Peter Adriaens gave clear explanations. (Q201) | 1 | 2 | 0 | 1 | 0 | 0 | 4.0 | 4.6 |
| Peter Adriaens stressed important points in lectures/discussions. (Q203) | 2 | 2 | 0 | 0 | 0 | 0 | 4.5 | 4.7 |
| Peter Adriaens appeared to have a thorough knowledge of the subject. (Q207) | 4 | 0 | 0 | 0 | 0 | 0 | 5.0 | 4.8 |
| Peter Adriaens acknowledged all questions insofar as possible. (Q216) | 3 | 1 | 0 | 0 | 0 | 0 | 4.8 | 4.8 |
| Peter Adriaens used class time well. (Q229) | 2 | 1 | 1 | 0 | 0 | 0 | 4.5 | 4.7 |

The medians are calculated from Winter 2021 data. University-wide medians are based on all UM classes in which an item was used. The school/college medians in this report are based on classes that are graduate level with enrollment of 1 to 15 in College of Engineering.

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

# Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

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

Date of Submission: 2023-08-22
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Civil & Environmental Engin<br>Subject: CEE<br>Catalog: 526 | Dept (Home): Civil & Environmental Engin<br>Subject: CEE<br>Catalog: 526 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>Design of Hydraulic Systems | Course Title (full title)<br>Design of Hydraulic Systems |
| ☐ | Abbreviated Title (20 char)<br>Des Hydraulic System | Abbreviated Title (20 char)<br>Des Hydraulic System |
| ☑ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Covers hydraulic design of pipe systems. This includes pump design, operation, cavitation, water hammer, control valves, and flow metering. Hydropower systems design includes hydraulic control structures, turbines, motor and generator operational principles, gravity dam stability analysis, and penstocks. Also covered are pumped hydro, powerhouses, economics, and pipe optimization. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 3 Graduate Min: 3<br>Undergraduate Max: 3 Graduate Max: 3 | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Civil & Environmental Engin  Catalog: 526

☐

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)<br>CEE 325 or equivalent | Advisory Prerequisite (254 char)<br>CEE 325 or equivalent |
| ☐ | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☐ | Credit Exclusions | Credit Exclusions |

☑

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

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

Cognizant Faculty Member Name: Lynn Shock  Cognizant Faculty Member Title:

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

Contact Person:  Email:  Phone:

CoE Curriculum Committee Representative: Roman D. Hry  **Print:** ROMAN D. HRYCIW  Date: 8/8.23

CoE Curriculum Committee Chair:  Print:  Date:

Home Department Chair:  Print: Yafen Tin  Date: 8/8/23

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair:  Print:  Date:

**DEPARTMENTAL/COLLEGE USE ONLY**

| Current: | Requested: |
| --- | --- |
| Course Description<br>Hydraulic design of piping systems including pumps and networks; pump system design including variable speed operation, cavitation, and wet well design; waterhammer and other transient phenomena; control valves and flow metering considerations; hydraulic control structures. | Course Description<br>Covers hydraulic design of pipe systems. This includes pump design, operation, cavitation, water hammer, control valves, and flow metering. Hydropower systems design includes hydraulic control structures, turbines, motor and generator operational principles, gravity dam stability analysis, and penstocks. Also covered are pumped hydro, powerhouses, economics, and pipe optimization. |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture): | Contact hours (lecture):<br>3 |
| Contact hours (recitation)<br>3 | Contact hours (recitation) |
| Contact hours (lab) | Contact hours (lab) |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Technical elective for Civil Engineering and Environmental Engineering

Special resources of facilities required for this course:

Supporting statement:
Revised description reflects that the scope has changed from the current description.
CEE has many 500-level courses that our undergrads also take for credit alongside our graduate students. There are limits to the number of 400-level credits that graduate students can count towards their graduate degrees. We also do not have enough available catalog numbers to change them all to 400-level even if we wanted to. Our course numbers have a specific pattern in which each "decade" belongs to a certain area, and students often take them in sequence. For one example, 212-312-412-512 all belong to our Structures group and should generally be taken in numerical order.

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Ann Arbor, MI 48109-1382
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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: 2023-09-18
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Elec Engin & Computer Sci<br>Subject: EECS<br>Catalog: 440 | Dept (Home):<br>Subject:<br>Catalog: |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>System Design of a Search Engine | Course Title (full title) |
| ☐ | Abbreviated Title (20 char)<br>SysDes Search Engine | Abbreviated Title (20 char) |
| ☐ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Design and development of a search engine. Topics include search engine internals, OS facilities, file systems, sockets, and threads. Students work in teams to write a complete multithreaded internet search engine from scratch. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 4 Graduate Min:<br>Undergraduate Max: 4 Graduate Max: | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Elec Engin & Computer Sci  Catalog: 440

☐

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)<br>EECS 281; (C or better, No OP/F)<br>Minimum grade requirement: C | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☐ | Credit Exclusions | Credit Exclusions |

☐

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

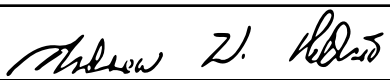
Graded Component
- ☑
- ☐
- ☐
- ☐
- ☐
- ☐

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

Cognizant Faculty Member Name: Nicole Hamilton  Cognizant Faculty Member Title:

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

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

| | | | |
|---|---|---|---|
| CoE Curriculum Committee Representative: |  | Print: Amir Kamil | Date: 9/08/23 |
| CoE Curriculum Committee Chair: | | Print: | Date: |
| Home Department Chair: |  | Print: Andrew DeOrio | Date: 09/11/2023 |
| Cross-Listed Department Chair: | | Print: | Date: |
| Cross-Listed Department Chair: | | Print: | Date: |
| Cross-Listed Department Chair: | | Print: | Date: |

**DEPARTMENTAL/COLLEGE USE ONLY**

| Current: | Requested: |
| --- | --- |
| Course Description<br>Design and development of a search engine. Topics include search engine internals, OS facilities, file systems, sockets, and threads. Students work in teams to write a complete multithreaded internet search engine from scratch. | Course Description |
| Class Length<br>Full term | Class Length |
| Contact hours (lecture):<br>3 | Contact hours (lecture): |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab)<br>2 | Contact hours (lab) |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
The course satisfies the major design experience in the CS-Eng major and the capstone requirement for students in the CS-LSA major.

Special resources of facilities required for this course:

Supporting statement:
The cognizant faculty member has left the university, and we do not plan to offer this course in the future.

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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: 2023-09-04
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Elec Engin & Computer Sci<br>Subject: EECS<br>Catalog: 448 | Dept (Home): Elec Engin & Computer Sci<br>Subject: EECS<br>Catalog: 448 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>Applied Machine Learning for Modeling Human Behavior | Course Title (full title)<br>Applied Machine Learning for Modeling Human Behavior |
| ☐ | Abbreviated Title (20 char)<br>Human-Centered ML | Abbreviated Title (20 char)<br>Human-Centered ML |
| ☐ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Machine learning, with a focus on human behavior, across multiple modalities including speech and text. Teams complete projects based primarily on their individual interests centered on modeling an aspect of human behavior. Prior experience with speech/language or other data modeling is not needed. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 4 Graduate Min: 4<br>Undergraduate Max: 4 Graduate Max: 4 | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Elec Engin & Computer Sci  Catalog: 448

☐

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)<br>EECS 445 | Advisory Prerequisite (254 char) |
| ☐ | Enforced Prerequisite (254 char)<br>[(EECS 281 and (MATH 214 or 217 or 296 or 417 or 419 or ROB 101)); (C or better; No OP/F)] or Graduate Standing in CSE<br><br>Minimum grade requirement: C | Enforced Prerequisite (254 char)<br>[(EECS 281 and (MATH 214 or 217 or 296 or 417 or 419 or ROB 101)); (C or better; No OP/F)] or Graduate Standing in CSE<br><br>Minimum grade requirement: C |
| ☐ | Credit Exclusions | Credit Exclusions |

☐

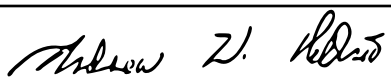
| Course Components | Graded Component |
|---|---|
| ☑ Lecture | ☑ |
| ☐ Seminar | ☐ |
| ☐ Recitation | ☐ |
| ☐ Lab | ☐ |
| ☑ Discussion | ☐ |
| ☐ Independent Study | ☐ |

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

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

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

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

| | | | |
|---|---|---|---|
| CoE Curriculum Committee Representative: |  | Print: Amir Kamil | Date: 9/08/23 |
| CoE Curriculum Committee Chair: | | Print: | Date: |
| Home Department Chair: |  | Print: Andrew DeOrio | Date: 09/11/2023 |
| Cross-Listed Department Chair: | | Print: | Date: |
| Cross-Listed Department Chair: | | Print: | Date: |
| Cross-Listed Department Chair: | | Print: | Date: |

**DEPARTMENTAL/COLLEGE USE ONLY**

| **Current:** | **Requested:** |
| --- | --- |
| Course Description<br>Machine learning, with a focus on human behavior, across multiple modalities including speech and text. Teams complete projects based primarily on their individual interests centered on modeling an aspect of human behavior. Prior experience with speech/language or other data modeling is not needed. | Course Description<br>Machine learning, with a focus on human behavior, across multiple modalities including speech and text. Teams complete projects based primarily on their individual interests centered on modeling an aspect of human behavior. Prior experience with speech/language or other data modeling is not needed. |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture):<br>3 | Contact hours (lecture):<br>3 |
| Contact hours (recitation)<br>1 | Contact hours (recitation)<br>1 |
| Contact hours (lab) | Contact hours (lab) |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Satisfies MDE/Capstone requirement for CS-LSA and CS-Eng majors.

Special resources of facilities required for this course:

Supporting statement:
The course is being adjusted to teach machine-learning content from scratch, so the advisory prerequisite of EECS 445 is no longer needed.

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

# Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

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

Date of Submission: 2023-08-31
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Engineering<br>Subject: ENGR<br>Catalog: 255 | Dept (Home): Engineering<br>Subject: ENGR<br>Catalog: 255 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>Introductory Multidisciplinary Engineering Project | Course Title (full title)<br>Introductory Multidisciplinary Engineering Project |
| ☐ | Abbreviated Title (20 char)<br>Multidis Eng Pro I | Abbreviated Title (20 char)<br>Multidis Eng Pro I |
| ☐ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Intro course in which students acquire, develop, and refine skills for success in the modern engineering design process using faculty OR faculty/Industry mentored, multidisciplinary, team-based, project work. Students will integrate: (1) knowledge from previous courses; (2) knowledge of engineering design process; and (3) professional skills (e.g., teamwork, project planning, communications, etc.). | |
| ☑ | Full Term Credit Hours<br>Undergraduate Min: 1 Graduate Min:<br>Undergraduate Max: 4 Graduate Max: | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student | |
| ☐ | Repeatability<br>☑ Course is Repeatable for Credit<br>Maximum number of repeatable credits: 12 | ☑ Course is Y graded<br>☑ Can be taken more than once in the same term |

Subject: Engineering Catalog: 255

☐

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)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☐ | Credit Exclusions | Credit Exclusions |

☐

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

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

Cognizant Faculty Member Name: Current Associate Dean, Undergraduate Education

Cognizant Faculty Member Title:

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

Contact Person: Email: Phone:

| | | | |
|---|---|---|---|
| CoE Curriculum Committee Representative: | Rachael Schmedlen | Print: Rachael Schmedlen | Date: 9/19/2023 |
| CoE Curriculum Committee Chair: | | Print: | Date: |
| Home Department Chair: | Kevin Pipe | Print: Kevin Pipe | Date: 9/18/23 |
| Cross-Listed Department Chair: | | Print: | Date: |
| Cross-Listed Department Chair: | | Print: | Date: |
| Cross-Listed Department Chair: | | Print: | Date: |

**DEPARTMENTAL/COLLEGE USE ONLY**

| Current: | Requested: |
| --- | --- |
| Course Description<br>Intro course in which students acquire, develop, and refine skills for success in the modern engineering design process using faculty OR faculty/Industry mentored, multidisciplinary, team-based, project work. Students will integrate: (1) knowledge from previous courses; (2) knowledge of engineering design process; and (3) professional skills (e.g., teamwork, project planning, communications, etc.). | Course Description<br>Intro course in which students acquire, develop, and refine skills for success in the modern engineering design process using faculty OR faculty/Industry mentored, multidisciplinary, team-based, project work. Students will integrate: (1) knowledge from previous courses; (2) knowledge of engineering design process; and (3) professional skills (e.g., teamwork, project planning, communications, etc.). |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture): | Contact hours (lecture): |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab)<br>2 - 6 | Contact hours (lab)<br>2 - 8 |

**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:
MDP is standardizing the allowable credit hour ranges across ENGR 255, 355, and 455: each level will have a minimum credit enrollment of 1 credit hour, and a maximum allowable credit enrollment of 4 credit hours (previously, each level allowed slightly different enrollment amounts). This will more accurately reflect the engineering design project requirements without impacting the current student experience. For example, the industry sponsored projects require 7 credits across 2 semesters (previously 255 was capped at 3 credit hours). We are also capping 455 enrollment at 4 credits (previously the course allowed up to 5 credit hours).

The current range of allowable credits for ENGR 255 is 1-3
New CARF will modify it to 1-4 credits.

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

# Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

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

Date of Submission: 2023-08-31
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Engineering<br>Subject: ENGR<br>Catalog: 455 | Dept (Home): Engineering<br>Subject: ENGR<br>Catalog: 455 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>Advanced Multidisciplinary Engineering Project | Course Title (full title)<br>Advanced Multidisciplinary Engineering Project |
| ☐ | Abbreviated Title (20 char)<br>Multidis Eng Pro 3 | Abbreviated Title (20 char)<br>Multidis Eng Pro 3 |
| ☐ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Advanced course in which students acquire, develop, and refine skills for success in the modern engineering design process using Faculty or Faculty/Industry mentored, multidisciplinary, team-based, project work. Students will integrate: (1) knowledge from previous courses; (2) knowledge of engineering design process; and (3) professional skills (e.g., teamwork, project planning, communications, etc.) | |
| ☑ | Full Term Credit Hours<br>Undergraduate Min: 1 Graduate Min:<br>Undergraduate Max: 4 Graduate Max: | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student | |
| ☑ | Repeatability<br>☑ Course is Repeatable for Credit<br>Maximum number of repeatable credits: 12 | ☑ Course is Y graded<br>☑ Can be taken more than once in the same term |

Subject: Engineering Catalog: 455

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

| | CURRENT LISTING | REQUESTED LISTING |
|---|---|---|
| ☐ | Advisory Prerequisite (254 char) | Advisory Prerequisite (254 char) |
| ☐ | Enforced Prerequisite (254 char)<br>Permission of Instructor<br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br>Permission of Instructor<br>Minimum grade requirement: |
| ☐ | Credit Exclusions | Credit Exclusions |

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

Cognizant Faculty Member Name: Current Associate Dean, Undergraduate Education

Cognizant Faculty Member Title:

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

Contact Person: Email: Phone:

| | | | |
|---|---|---|---|
| CoE Curriculum Committee Representative: | Rachael Schmedlen | Print: Rachael Schmedlen | Date: 9/19/2023 |
| CoE Curriculum Committee Chair: | | Print: | Date: |
| Home Department Chair: | Kevin Pipe | Print: Kevin Pipe | Date: 9/18/23 |
| Cross-Listed Department Chair: | | Print: | Date: |
| Cross-Listed Department Chair: | | Print: | Date: |
| Cross-Listed Department Chair: | | Print: | Date: |

**DEPARTMENTAL/COLLEGE USE ONLY**

| Current: | Requested: |
| --- | --- |
| Course Description<br>Advanced course in which students acquire, develop, and refine skills for success in the modern engineering design process using Faculty or Faculty/Industry mentored, multidisciplinary, team-based, project work. Students will integrate: (1) knowledge from previous courses; (2) knowledge of engineering design process; and (3) professional skills (e.g., teamwork, project planning, communications, etc.) | Course Description<br>Advanced course in which students acquire, develop, and refine skills for success in the modern engineering design process using Faculty or Faculty/Industry mentored, multidisciplinary, team-based, project work. Students will integrate: (1) knowledge from previous courses; (2) knowledge of engineering design process; and (3) professional skills (e.g., teamwork, project planning, communications, etc.) |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture): | Contact hours (lecture): |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab)<br>4 - 10 | Contact hours (lab)<br>2 - 8 |

**Additional Info:**

Submitted by:
Home dept

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

Special resources of facilities required for this course:

Supporting statement:
MDP is standardizing the allowable credit hour ranges across ENGR 255, 355, and 455: each level will have a minimum credit enrollment of 1 credit hour, and a maximum allowable credit enrollment of 4 credit hours (previously, each level allowed slightly different enrollment amounts). This will more accurately reflect the engineering design project requirements without impacting the current student experience. For example, the industry sponsored projects require 7 credits across 2 semesters (previously 255 was capped at 3 credit hours). We are also capping 455 enrollment at 4 credits (previously the course allowed up to 5 credit hours).

The current range of allowable credits for ENGR 455: 2-5
The max number of repeatable credits: 15.

New CARF will modify it to 1-4 credits; and cap the total repeatable credits at 12.

# 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

**☑ CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested

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

Date of Submission: 2023-08-01
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Naval Arch & Marine Engin<br>Subject: NAVARCH<br>Catalog: 332 | Dept (Home): Naval Arch & Marine Engin<br>Subject: NAVARCH<br>Catalog: 332 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☑ | Course Title (full title)<br>Marine Power and Energy | Course Title (full title)<br>Marine Power and Energy II |
| ☑ | Abbreviated Title (20 char)<br>MarinePowerEnergy | Abbreviated Title (20 char)<br>MarinePowerEnergy II |
| ☐ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Marine diesel engines, steam turbines, gas turbines, combined plants. Fuels, emissions. Mechanical power transmission, reduction gears. Electrical power generation, transmission and distribution. Propeller selection and engine-propeller matching. System reliability, design of mechanical, integrated electric and hybrid propulsion systems. Boat and ship auxiliary systems. Marine engineering systems design project. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 4 Graduate Min:<br>Undergraduate Max: 4 Graduate Max: | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Naval Arch & Marine Engin  Catalog: 332

☐

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)<br>EECS 314, NA 235 or ME 235, co-requisite: NA 321 | Advisory Prerequisite (254 char)<br>NA 331, NA 235 or ME 235, co-requisite: NA 321 |
| ☐ | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☐ | Credit Exclusions | Credit Exclusions |

☐

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

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

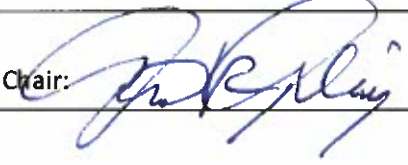
Cognizant Faculty Member Name: David Singer  Cognizant Faculty Member Title: Professor

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

Contact Person:  Email:  Phone:

CoE Curriculum Committee Representative:  Print: ANCHAL SAREEN Date: 09/05/23

CoE Curriculum Committee Chair:  Print:  Date:

Home Department Chair:  Print: David R Dowling Date: 9/6/23

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair: Print: Date:

**DEPARTMENTAL/COLLEGE USE ONLY**

| **Current:** | **Requested:** |
|---|---|
| Course Description<br>Marine diesel engines, steam turbines, gas turbines, combined plants. Fuels, emissions. Mechanical power transmission, reduction gears. Electrical power generation, transmission and distribution. Propeller selection and engine-propeller matching. System reliability, design of mechanical, integrated electric and hybrid propulsion systems. Boat and ship auxiliary systems. Marine engineering systems design project. | Course Description<br>Marine diesel engines, steam turbines, gas turbines, combined plants. Fuels, emissions. Mechanical power transmission, reduction gears. Electrical power generation, transmission and distribution. Propeller selection and engine-propeller matching. System reliability, design of mechanical, integrated electric and hybrid propulsion systems. Boat and ship auxiliary systems. Marine engineering systems design project. |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture):<br>4 | Contact hours (lecture):<br>4 |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab) | Contact hours (lab) |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Required course for all students in NAME BSE program

Special resources of facilities required for this course:

Supporting statement:
Changing the title from "Marine Power and Energy" to "Marine Power and Energy II" to reflect continuity with NA 331 ("Marine Power and Energy I).

# 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

☑ CHECK APPROPRIATE BOXES FOR ALL CHANGES

Action Requested

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

Date of Submission: 2023-08-01
Effective Term: Fall 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | CURRENT LISTING | REQUESTED LISTING |
|---|---|---|
| ☐ | Dept (Home): Naval Arch & Marine Engin<br>Subject: NAVARCH<br>Catalog: 340 | Dept (Home): Naval Arch & Marine Engin<br>Subject: NAVARCH<br>Catalog: 340 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>Marine Dynamics I | Course Title (full title)<br>Marine Dynamics I |
| ☐ | Abbreviated Title (20 char)<br>Marine Dyn I | Abbreviated Title (20 char)<br>Marine Dyn I |
| ☐ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Structural vibration; one and multi-degree of freedom models. Forced steady state response. Fourier series; definition and application to frequency response. Introduction to random processes and applications in linear systems. Rigid body motion of floating structures. Sea wave excitation. Hydrodynamic added mass and damping; anti-roll tanks. Ship maneuvering; directional stability and steady turning. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 4 Graduate Min:<br>Undergraduate Max: 4 Graduate Max: | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Naval Arch & Marine Engin  Catalog: 340

☐

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)<br>"ME 240, co-requisite NA 321" | Advisory Prerequisite (254 char)<br>ME 240 |
| ☐ | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☐ | Credit Exclusions<br>none | Credit Exclusions<br>none |

☐

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

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

Cognizant Faculty Member Name: Yulin Pan  Cognizant Faculty Member Title: Professor

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

Contact Person:  Email:  Phone:

CoE Curriculum Committee Representative: [signature]  Print: ANCHAL SAREEN  Date: 09/05/23

CoE Curriculum Committee Chair:  Print:  Date:

Home Department Chair: [signature]  Print: David R Dowling  Date: 9/6/23

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair: Print: Date:

**DEPARTMENTAL/COLLEGE USE ONLY**

| Current: | Requested: |
|---|---|
| Course Description<br>Structural vibration; one and multi-degree of freedom models. Forced steady state response. Fourier series; definition and application to frequency response. Introduction to random processes and applications in linear systems. Rigid body motion of floating structures. Sea wave excitation. Hydrodynamic added mass and damping; anti-roll tanks. Ship maneuvering; directional stability and steady turning. | Course Description<br>Structural vibration; one and multi-degree of freedom models. Forced steady state response. Fourier series; definition and application to frequency response. Introduction to random processes and applications in linear systems. Rigid body motion of floating structures. Sea wave excitation. Hydrodynamic added mass and damping; anti-roll tanks. Ship maneuvering; directional stability and steady turning. |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture):<br>4 | Contact hours (lecture):<br>4 |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab) | Contact hours (lab) |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Degree Requirement

Special resources of facilities required for this course:

Supporting statement:
Remove NA 321 from list of co-requisites. NA 340 is offered in term before NA 321.

# 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

☑ CHECK APPROPRIATE BOXES FOR ALL CHANGES

Action Requested

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

Date of Submission: 2023-08-01
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>**Date Received:**<br>**Date Completed:**<br>**Completed By:** |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Naval Arch & Marine Engin<br>Subject: NAVARCH<br>Catalog: 420 | Dept (Home):<br>Subject:<br>Catalog: |
| ☐ | ☑ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number<br>CLIMATE-CLIMATE-420,<br>ENSCEN-ENSCEN-420 | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>Environmental Ocean Dynamics | Course Title (full title) |
| ☐ | Abbreviated Title (20 char)<br>Env Ocean Dyn | Abbreviated Title (20 char) |
| ☐ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Physical conditions and physical processes of the oceans; integration of observations into comprehensive descriptions and explanations of oceanic phenomena. Emphasis on numerical wave and current prediction, optical and acoustical properties of sea water, currents, tides, waves and pollutant transport. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 4 Graduate Min: 4<br>Undergraduate Max: 4 Graduate Max: 4 | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Naval Arch & Marine Engin  Catalog: 420

☐

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)<br>NA 320 or AOSS 305 or CEE 325 | Advisory Prerequisite (254 char) |
| ☐ | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☐ | Credit Exclusions | Credit Exclusions |

☐

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

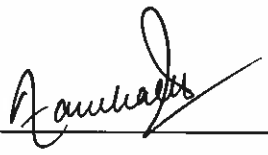
Graded Component
- ☑
- ☐
- ☐
- ☐
- ☐
- ☐

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

Cognizant Faculty Member Name: David Singer  Cognizant Faculty Member Title: Professor

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

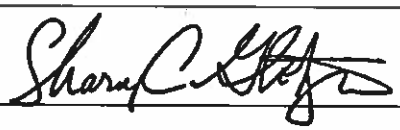
Contact Person:  Email:  Phone:

CoE Curriculum Committee Representative:  Print: ANCHAL SAREEN Date: 09/14/23

CoE Curriculum Committee Chair:  Print:  Date:

Home Department Chair:  Print: David R Dowling Date: 9/14/23

Cross-Listed Department Chair:  Print: Gretchen Keppel-Aleks Date: 16 Aug 2023

Cross-Listed Department Chair:  Print: Sharon C. Glotzer Date: 9/13/23

Cross-Listed Department Chair: Print: Date:

**DEPARTMENTAL/COLLEGE USE ONLY**

| **Current:** | **Requested:** |
|---|---|
| Course Description<br>Physical conditions and physical processes of the oceans; integration of observations into comprehensive descriptions and explanations of oceanic phenomena. Emphasis on numerical wave and current prediction, optical and acoustical properties of sea water, currents, tides, waves and pollutant transport. | Course Description |
| Class Length<br>Full term | Class Length |
| Contact hours (lecture):<br>4 | Contact hours (lecture): |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab) | Contact hours (lab) |

**Additional Info:**

Submitted by:
Cross-listed dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
Course no longer part of NAME Major - please delete

# 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

**☑ CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested

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

Date of Submission: 2023-08-01
Effective Term: Fall 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | CURRENT LISTING | REQUESTED LISTING |
|---|---|---|
| ☐ | Dept (Home): Naval Arch & Marine Engin<br>Subject: NAVARCH<br>Catalog: 475 | Dept (Home): Naval Arch & Marine Engin<br>Subject: NAVARCH<br>Catalog: 475 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☐ | Course Title (full title)<br>Capstone Design Project | Course Title (full title)<br>Capstone Design Project |
| ☐ | Abbreviated Title (20 char)<br>Capstone Project | Abbreviated Title (20 char)<br>Capstone Project |
| ☐ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Small teams of up to 4 students create, develop, and document original marine designs to contract design level. Projects typically involve a ship, yacht, submersible, or offshore system. Involves extensive project planning and weekly progress reporting. Extensive written and oral presentation of the project. Significant design CAD effort. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 4 Graduate Min: 4<br>Undergraduate Max: 4 Graduate Max: 4 | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Naval Arch & Marine Engin  Catalog: 475

☐

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)<br>NA 470 | Advisory Prerequisite (254 char) |
| ☑ | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br>NA 470<br>Minimum grade requirement: C- |
| ☐ | Credit Exclusions<br>none | Credit Exclusions<br>none |

☐

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

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

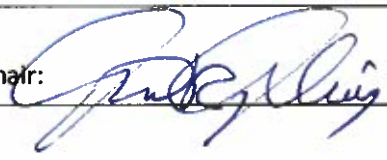
Cognizant Faculty Member Name: Matthew Collette  Cognizant Faculty Member Title: Professor

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

Contact Person:  Email:  Phone:

CoE Curriculum Committee Representative:   Print: ANCHAL SAREEN  Date: 09/05/23

CoE Curriculum Committee Chair:  Print:  Date:

Home Department Chair:   Print: David R Dowling  Date: 9/6/23

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair:  Print:  Date:

Cross-Listed Department Chair: Print: Date:

**DEPARTMENTAL/COLLEGE USE ONLY**

| **Current:** | **Requested:** |
|---|---|
| Course Description<br>Small teams of up to 4 students create, develop, and document original marine designs to contract design level. Projects typically involve a ship, yacht, submersible, or offshore system. Involves extensive project planning and weekly progress reporting. Extensive written and oral presentation of the project. Significant design CAD effort. | Course Description<br>Small teams of up to 4 students create, develop, and document original marine designs to contract design level. Projects typically involve a ship, yacht, submersible, or offshore system. Involves extensive project planning and weekly progress reporting. Extensive written and oral presentation of the project. Significant design CAD effort. |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture):<br>3 | Contact hours (lecture):<br>3 |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab)<br>2 | Contact hours (lab)<br>2 |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Degree Requirement

Special resources of facilities required for this course:
Use of NAME Undergraduate Marine Design Laboratory.

Supporting statement:
NA 470 now required prerequisite to ensure academic preparation of students.

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

# Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

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

Date of Submission: 2023-08-17
Effective Term: Winter 2024

| | | |
|---|---|---|
| ☑ | Course Offered<br>☑ Indefinitely<br>☐ One term only | **RO USE ONLY**<br>Date Received:<br>Date Completed:<br>Completed By: |

| | **CURRENT LISTING** | **REQUESTED LISTING** |
|---|---|---|
| ☐ | Dept (Home): Robotics<br>Subject: ROB<br>Catalog: 511 | Dept (Home): Robotics<br>Subject: ROB<br>Catalog: 511 |
| ☐ | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number | ☐ Course is Cross-Listed with Other Departments<br>Department / Subject / Catalog Number |
| ☑ | Course Title (full title)<br>Advanced Robot Operating Systems | Course Title (full title)<br>Mobile Manipulation Systems |
| ☑ | Abbreviated Title (20 char)<br>Adv Robot Oper Sys | Abbreviated Title (20 char)<br>Mobile Manipulation |
| ☑ | Course Description (Please limit to 50 words and attach separate sheet if necessary)<br>Introduction to computational models, algorithms, and software systems for full-stack autonomous robot control that generalizes across a wide variety of mobile manipulation platforms. Topics include robot description conventions, path and motion planning, reactive control, forward and inverse kinematics, dynamical simulation, numerical integration, and robot middleware design. Extensive programming. | |
| ☐ | Full Term Credit Hours<br>Undergraduate Min: 3 Graduate Min: 3<br>Undergraduate Max: 3 Graduate Max: 3 | Half Term Credit Hours<br>Undergraduate Min: Graduate Min:<br>Undergraduate Max: Graduate Max: |
| ☐ | Course Credit Type<br>Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student | |
| ☐ | Repeatability<br>☐ Course is Repeatable for Credit<br>Maximum number of repeatable credits: | ☐ Course is Y graded<br>☐ Can be taken more than once in the same term |

Subject: Robotics Catalog: 511

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

| | CURRENT LISTING | REQUESTED LISTING |
|---|---|---|
| ☑ | Advisory Prerequisite (254 char)<br>Linear Algebra (MATH 214,217,417,419 or equivalent) and Programming (EECS 280, 402 or equivalent) | Advisory Prerequisite (254 char)<br>Linear Algebra (MATH 214, 217, 417, 419 or equivalent) and Programming (EECS 280, EECS 402, ROB 502 or equivalent) |
| ☐ | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: | Enforced Prerequisite (254 char)<br><br>Minimum grade requirement: |
| ☑ | Credit Exclusions | Credit Exclusions<br>Only 1 course may earn credit from ROB 320, ROB 380, and EECS 367 |
| ☑ | Course Components<br>☑ Lecture<br>☐ Seminar<br>☐ Recitation<br>☐ Lab<br>☐ Discussion<br>☐ Independent Study<br>Graded Component<br>☑<br>☐<br>☐<br>☐<br>☐<br>☐<br>Terms Typically Offered<br>☑ Fall<br>☑ Winter<br>☐ Spring<br>☐ Summer<br>☐ Spring/Summer | |

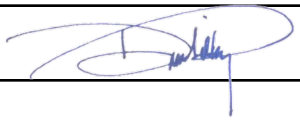
Cognizant Faculty Member Name: Chad Jenkins Cognizant Faculty Member Title:

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

Contact Person: Kayla Dombrowski Email: kakelle@umich.edu Phone: 734.936.7999

CoE Curriculum Committee Representative:  Print: Odest Chadwicke Jenkins Date: 8/31/2023

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair:  Print: Dawn Tilbury Date: 9-12-2023

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

**DEPARTMENTAL/COLLEGE USE ONLY**

| **Current:** | **Requested:** |
|---|---|
| Course Description<br>Introduction to computational models, algorithms, and software systems for full-stack autonomous robot control that generalizes across a wide variety of machines. Topics include robot description languages, path and motion planning, reactive control, forward and inverse kinematics, dynamical simulation, numerical integration, and robot middleware design. Extensive programming. | Course Description<br>Introduction to computational models, algorithms, and software systems for full-stack autonomous robot control that generalizes across a wide variety of mobile manipulation platforms. Topics include robot description conventions, path and motion planning, reactive control, forward and inverse kinematics, dynamical simulation, numerical integration, and robot middleware design. Extensive programming. |
| Class Length<br>Full term | Class Length<br>Full term |
| Contact hours (lecture):<br>3 | Contact hours (lecture):<br>3 |
| Contact hours (recitation) | Contact hours (recitation) |
| Contact hours (lab) | Contact hours (lab) |

**Additional Info:**

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
Satisfies the Acting or Reasoning requirement for the Masters and Doctoral Robotics Programs

Special resources of facilities required for this course:

Supporting statement:
This course is being renamed to distinguish it from ROB 320. While both courses will cover similar content for robot planning and kinematics, ROB 511 will provide a deeper treatment of the underlying computational and algorithmic concepts with simulated robots. ROB 320 will be focusing more on systems issues, such as interprocess communication, and multithreading, for real robots. The current structure and syllabus for the course is available from the course website at http://autorob.org.